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Quod si cui mortalium cordi et curæ sit, non tantum inventis hærere, atque iis uti, sed ad ulteriora penetrare; atque non disputando adversarium, sed opere naturam vincere; denique non belle et probabiliter opinari, sed certo et ostensive scire; tales, tanquam veri scientiarum filii, nobis (si videbitur) se adjungant.

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I.—*On the Geological Structure of the Wealden District and of the Bas Boulonnais.*

By WILLIAM HOPKINS, Esq., M.A., F.R.S., F.G.S. &c. &c.

[Read February 3rd, 1841.]

INTRODUCTION.

GEOLOGISTS have long recognized the fact of the approximate parallelism of lines of dislocation in those districts in which systems of such lines are found to exist; and in my memoir on Physical Geology, published in vol. vi. part 1. of the Transactions of the Cambridge Philosophical Society, I have shown that such parallelism would, in many cases and under the most simple and probable conditions, be the necessary consequence of the simultaneous action of an elevating force acting beneath extensive portions of the crust of the globe. I also demonstrated that two systems of parallel dislocations might be produced by the same elevating force, the direction of the one system being perpendicular to that of the other. I also pointed out the circumstances under which, according to theory, there would be a necessary deviation from parallelism in these systems, and I indicated the relations which such deviations would bear, in certain general cases, to the boundary of the disturbed district, and to the particular configuration of its surface. On these points I proceeded farther, in theory, than geologists had gone in observation. There are still few districts, even in those countries with which we are geologically best acquainted, where observations have been made in sufficient detail to bring this subject, as a branch of descriptive geology, to the point to which I have carried it in theory.

Under these circumstances my attention was directed to the district of the Weald in Kent, Surrey and Sussex, as one in which the phænomena of elevation might be expected to accord with correct theoretical results in a greater degree than in many other cases, on account of the regularity of its boundary, and the apparent absence of the effects of that more violent, local, or irregular action of the elevating force, which it must ever be impossible to reduce to calculation.

When I came, however, to examine the descriptions which we already possessed of the geological structure of the district, I found them too imperfect and fragmentary to enable me to detect with certainty the accurate laws of the phænomena, or to allow me to appeal to them as tests of the accuracy of my theoretical views.

The general anticlinal structure of this tract has been long known. Dr. Mantell and Mr. Lyell recognized also the existence of several longitudinal anticlinal lines, running generally in an east and west direction. Dr. Mantell had also made several insulated observations on the dip of the strata in different localities; but I am not aware that either of these gentlemen so far directed his attention to observations of this kind, as to determine accurately the position or extent of any one of the lines of elevation, the existence of which they had recognized, much less to detect the true law by which (as we shall see hereafter) these lines are related. Dr. Fitton has also made several observations on the structure of the Weald, and has given some valuable sections in his memoir "On the Formations below the Chalk," a work to which I have constantly referred in my own investigations. Only one part of the Wealden district, however (the south-western), has been hitherto examined, with reference to its structure, in much detail. This portion, lying more especially in the neighbourhood of Pulborough, was carefully investigated by Mr. Martin, and described by him in a memoir published some years ago. The author in this memoir enters into some speculations concerning the general character of the whole tract comprised within the limits of the Wealden denudation, and especially directs attention to its transverse drainage. Almost every one of its rivers, in some parts of its course, passes nearly perpendicularly through one or more of the longitudinal ridges of the district, and finally escapes from it by passing transversely through the bounding chalk escarpment. It seems almost impossible to render any account of this frequent transverse direction of the river-courses, without referring it to the original existence of transverse fissures, as Mr. Martin has done. He appears to have been the first to recognize distinctly what I conceive to be the real structure of the district in this respect, but his views were for the most part conjectural, except so far as they were applied to the neighbourhood of Pulborough. With respect to other parts of the district, they appeared to rest principally on analogy, and not on facts furnished in detail by direct observation. I determined therefore to attempt to supply the deficiency of evidence in that large portion of the Wealden district which had not been examined in sufficient detail; and since the analogy which the denudation of the Bas Boulonnais bears to that of the Weald, and the relative positions of the two districts, indicate the great probability of their elevations having been contemporaneous, I considered it necessary, in order to render the investigation complete,

to examine also the Bas Boulonnais, for the purpose of ascertaining whether its structure bears any definite relation to that of the Weald. The first part of the communication which I have now to make to the Society contains the results of these investigations; the second part will contain a discussion of theoretical notions, founded on a general view of the phænomena of the Wealden districts, together with those of the adjoining country as described by other observers.

In stating what has hitherto been done with respect to the geological structure of this district, I may notice a section made by the late Mr. Farey from the North to the South Downs, across the centre of the Weald. In the lines of elevation which it recognizes, this section accords with my own observations; but many of its details are evidently so entirely hypothetical, that I should not venture to appeal to it on any of the minuter points of structure which it professes to exhibit. It is also impossible, in noticing the labours of previous observers, to omit those of Dr. Mantell, whose name has long been so closely associated with the geology of the south-east of England. If I have been able to make but little use of his observations, it is that our objects have been entirely different; so that his work, abounding as it does with interesting matter in the department of the science to which it is especially devoted, contains but few observations bearing immediately on the objects of my own researches.

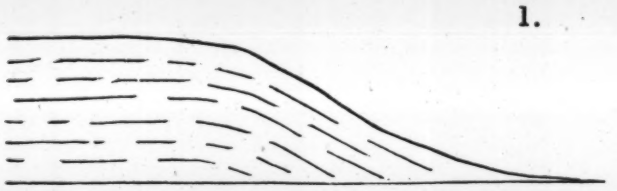
§ 1. The Wealden District.

It would be useless to enter here into any detailed description of a tract of country of which the general geological features are so well known as those of the district comprised within the bounds of the Wealden denudation. It will only be necessary to state, that the tract to which my researches have been principally confined is bounded on the English side of the Channel by the clearly-defined escarpment of the chalk, extending from the coast near Folkstone, in a north-westerly direction, by the north-east of Ashford and of Maidstone and north of Seven Oaks, and thence in a westerly direction by Reigate, Dorking, Guildford and Farnham, after which it passes to the east of Alton and round Petersfield, whence it proceeds in a nearly easterly, and finally, in a nearly south-easterly direction by Lewes, to the coast at Beachy Head. The Bas Boulonnais is bounded by an exactly similar escarpment of chalk, commencing on the north at Wissant, proceeding by Desvres and Samer, till it again meets the coast seven or eight miles south of Boulogne; its extent from north to south, parallel with the coast, being about twenty, and that from east to west, along the road from Boulogne to St. Omer, about twelve miles. It requires but little effort of the imagination to connect the two extremities of

these escarpments at Folkstone and Wissant, as well as those at Beachy Head and the southern point of the Bas Boulonnais. Thus connected, the English and the French districts, with the intervening portion of the Channel, would form a tract which may be described generally as an elongated oval, but having a curvilinear instead of a rectilinear axis. Its length is about 150 miles, and its greatest breadth about 40 miles.

Before I proceed to the particular description of phænomena, it may be desirable to explain the precise sense in which I have used certain expressions in this paper. There are frequent instances in the Wealden district in which the section of a longitudinal elevation is such as represented in the annexed diagram, the beds dipping (and in many cases with great rapidity) in one direction, but preserving a

1.



sensible horizontality in the opposite one. This is obviously not an *anticlinal* arrangement, nor can the line from which the descending dip commences be termed with propriety an *anticlinal line*. I have called it a *line of flexure*, finding it almost essential to employ some distinctive term to denote it. All anticlinal and synclinal lines, lines of flexure, of fault, &c., I have frequently designated by the general term of *lines of elevation*.

I shall now commence my description with an account of the central range of the Wealden district, consisting almost entirely of Hastings Sand.

Hastings Anticlinal Line.—A well-defined ridge, forming the most striking feature in this part of the district, runs from Battle to the north of Hastings. The Hastings anticlinal line may be traced with great precision from within a mile of Battle to the coast. It appears to lie just on the northern side of the summit of the ridge, and runs in a straight line to meet the coast at a point south-east of Fairlight church. The northern side is the best defined, owing to the rapid dip of the beds on that side, which in some places is not less than 50° or 60° in a direction perpendicular to that of the ridge. On the southern side the average dip, though considerable, is not nearly so great. The point where this line meets the coast is well defined in the splendid natural section which the cliffs afford. It should be observed, however, that the general direction of the coast makes an angle of about 45° with that of the anticlinal line, and therefore makes about the same angle with the line of greatest dip, so that the apparent dip of the beds in the cliff is much less than their real dip. It is not however very great, and is much more regular than in the neighbourhood of Battle. I could not trace the

anticlinal line quite up to that place, to the north of which a distinct system of lines commences.

Brightling and Battle Lines.—Brightling Down is one of the highest points in this part of the country, its height being stated to be 646 feet. The anticlinal line passes through its summit, where it is extremely well defined, the dip both on the north and south being very considerable. It extends westward through the northern extremity of Heathfield Park, beyond which I could detect no distinct evidence of its continuation. To the eastward it does not appear to be distinctly continued beyond the village of Brightling, which is situated on the extremity of that part of the range of hill. Immediately on the south of Brightling Hill is another on which Dallington is situated, and which is continued more or less distinctly to Battle. This line however is not anticlinal immediately to the south of Brightling Down, nor is the Brightling line transferred to it, where this subordinate range passes farther east than the Brightling one; for I distinctly ascertained the general dip to be to the south, on the north side of the Dallington range, about Darvel Beach and in Limekiln Wood.

Further to the east, we obtain an instructive section along the new road from Battle to St. John's Cross, which runs nearly in a straight line between those places. Immediately to the north of Battle, the hill on which the windmills stand is shown by the new cuttings to be strongly anticlinal. The direction of the anticlinal line appeared to coincide with that of the hill, and to be two points to the south of east (E.S.E.). It is not continued far to the east, nor to the west. I conceive it to be independent both of the Hastings and Brightling lines. Proceeding northward towards St. John's Cross, we recognize a synclinal line in crossing the valley and small stream about a mile and a half from Battle; and another at a point of the road east of Mountfield. The exact position of the anticlinal between them is not very distinctly marked, but must be very nearly as indicated on the map. North of the last-mentioned synclinal line the beds rise rapidly up to St. John's Cross, on the north of which they appear to descend very gradually to the river at Robertsbridge, thus forming a third anticlinal line between Battle and that place. Of the two northernmost I had no means of determining the exact directions.

On the west of the new road above mentioned, the dip is said to be very irregular, and the country much dislocated. The irregularity is probably more apparent than real, as far as regards the positions of the lines of elevation. There is scarcely any irregularity in the dip along the new road, which affords an almost continuous section from Battle to St. John's Cross, though the existence of great irregularity might have been inferred from merely insulated observations along that section. Still we might reasonably expect some irregularity about the

point where the Brightling line terminates, and the three lines above described commence. It is certain also that there has been more than ordinary disturbance along the whole of the Brightling and Hastings lines. In the neighbourhood of Battle, particular beds of limestone have been worked to a considerable extent, and can be easily identified. By means of these beds a fault has been detected in Archer's Wood of sixty fathoms, as stated by Dr. Mantell*. Indications of great dislocation are observable also in many other places.

On the east of the new road from Battle to St. John's Cross, it would seem impossible to identify the three lines above mentioned to any considerable distance. The valley which passes down to Winchelsea (at least the upper part of it) may, possibly, have originated in a dislocation connected with the central line. At Brede (on the northern side) one of the beds of hard limestone above mentioned is worked for repairing the roads, and I was informed that the same bed was found at the level of the river, a point lower by several hundred feet than the village. Supposing this to be the case, there must be an enormous fault running along this part of the valley. The dip on both sides of the valley is to the east of north. On the north of the valley also, half-way between Sedlescomb and the Udymer great road, a new cut showed the strata rising southward at an angle of about 25° to a ridge running south of east, with a parallel valley on the north. Along this ridge I have no doubt of the existence of a line of elevation.

I have been the more particular in the description of the phænomena between Battle and Brightling, because the line terminating at one of those places has been represented as a continuation of the one terminating at the other, the whole line having thus been made to assume a somewhat irregular and anomalous form. This is, in fact, one of those localities in which insulated observations are sure to lead to erroneous conclusions respecting true geological structure, the discovery of which can frequently be effected only by the most careful and laborious research†.

Bexhill Line.—In proceeding westerly along the coast from Hastings, the natural

* Geology of the South-east of England, p. 221.

† Dr. Mantell has remarked, "The dip of the strata around Pounceford, as in all the surrounding district, is as various as possible, the disruption of the beds being so great, that faults, and *horses*, as the risings of the strata are called in Sussex, are observable in almost every quarry."—*Geology of the South-east of England*, p. 225. I think it necessary to notice this passage as coming from the eminent geologist from whose work it is quoted, lest it should be thought to militate against my own conclusions in which I assert the existence of so much regularity and law in the phænomena of elevation of the district of the Weald. There are probably few very disturbed districts in which insulated observations might not appear to justify such a remark as that just quoted; but it is equally certain that patient research, with a clear geometrical conception of the subject, will rarely fail to evolve from such seeming confusion, the most unequivocal laws of geological structure. Pounceford is situated a little to the north of Brightling anticlinal line. The variations of dip in that neighbourhood are much more in *degree* than in *direc-*

section formed by the cliff exhibits the beds of Hastings sand dipping apparently towards the west, their real mean dip being about two points west of south. This dip is continued to St. Leonards, where it takes the opposite direction. In a newly-cut road in the direction of greatest dip, about a mile west of that place, the inclination of the beds was far more distinctly exhibited than in the face of the cliff, the direction of which is not far from that of the strike. This reverse dip is distinctly continued to a point south-east of Bexhill, where the south-westerly dip is again resumed, and a little farther to the west the beds are brought for a short space into nearly a vertical position. The disturbance has produced a fault, the magnitude of which is too great to be determined by the section of the cliff, which does not exceed 20 or 30 feet in height. At some distance beyond the fault, the gentle dip of the beds (in a direction about S.S.W.) is again resumed. I did not extend the examination further.

A range of low hill is represented on the Ordnance Map, running from Bexhill to Ninfield. It was difficult to detect distinct evidence of structure along this ridge; but I obtained what I considered to be a satisfactory observation, which gave the north-easterly dip about a mile and a half north-west of Bexhill. I was thus led to conclude that the line of elevation, which doubtless accompanies this range for at least two or three miles from the sea, passes along its southern side after passing to the north of Bexhill. I could detect no trace of it near Ninfield.

Hurstmonceaux Line.—A low range of hill similar to that last mentioned, and in a direction parallel to it, passes to the north of Hurstmonceaux Park. The part called Windmill Hill is distinctly anticlinal. There can be no doubt that a line of elevation coincides with the general direction of the hill.

Transverse Fractures of the Hastings Line.—About half-way between Battle and Hastings the new road has been cut through High Beach Hill, and exhibits a fine section of a great disturbance, produced by a transverse fracture which has given a local anticlinal arrangement to the beds, and formed a short transverse anticlinal line. The hill and transverse valley on the north of it, by the top of which the road passes, have evidently originated in this cross dislocation.

The new road above mentioned runs, nearly in a direct line, from High Beach Hill to Hastings, and affords the evidence of another transverse fracture along the valley immediately on the west of Silver Hill. There appears to be an enormous fault, as indicated by the two portions of what is I think unquestionably the same

tion. The existence of such variations is not more certain than that the general dip is somewhat to the east of north, as stated by Dr. Mantell himself to be the case, at the place just mentioned. The structure of the Brightling ridge is in fact remarkably distinct.

stratum, and belonging to Dr. Mantell's Ashburnham beds. The fault is probably several hundred feet. The valley along which it appears to run is marked in the Ordnance Map by the course of a rivulet south-east and south of the village of Hallington.

Another great fault is also exhibited by the cutting of the same road at its entrance into the western extremity of Hastings. Dark, shaly, argillaceous beds there abut directly against the massive beds of white sandstone. The direction of the fault is very nearly perpendicular to the Hastings line. I could find no distinct evidence of it at other points more remote from the coast, though I think it probable, from external indications, that it is continued across the central ridge, on the east of the village of Ore.

Wadhurst and Hawkshurst Line.—About seven miles north of the westerly portion of the Brightling line is a range of hill, distinctly marked on the Ordnance Map, passing through Wadhurst. About three-quarters of a mile north of Wadhurst, I observed a rapid dip to the north. At Best Beech Hill the beds are much disturbed, and somewhat irregularly; and a little north of Mark Cross (near the western extremity of the ridge), in a large quarry near the road to Tunbridge Wells, the dip is observed to be rapid and to the north. At Mark Cross and south of it the dip is very small, but tends towards the south. Likewise in a large pit on the great road near to and south of Wadhurst, the dip, though not large, is distinctly to the south. These observations prove the existence of an anticlinal line along the ridge above mentioned. Its continuation to Hawkshurst is distinctly proved by observations immediately on the north and south of the line, the dip being generally from 5° to 10°*. I was unable to trace it with any distinctness farther than Meagrane Hill. The hills of Sandhurst and Bonhurst appear to have been the result of surrounding denudation rather than of elevation.

About three miles to the north-east of these latter places is a range of hill through Rolvenden and Bennenden, which does not appear however to be connected with any continuous line of curvature of the strata. On the contrary, in returning from Bennenden to Hawkshurst I obtained a series of observations which gave the dip uniformly east of north, proving the continuity of the nearly north-easterly dip as far as the axis of the Bennenden range. From Rolvenden to Bennenden I could find no evidence of any sensible inclination of the beds. This range does not in fact form a very decided feature, and is probably due to denudation.

* The dips on the north of the line were clearly observed on the road from Ticehurst to Newhenden, near Flimwell; also about Hawkshurst. To the N.E. of Ticehurst near Pillory Farm, and in some large quarries near Piles Heath (Ordnance Map) and Bedgbury Park, the dip was nearly 20°. The position of this line is determined very accurately.

The western portions of this line and of the Brightling line comprise between them an extensive valley, the formation of which would probably in the first instance be the necessary consequence of the elevation of these lines. Its drainage is somewhat remarkable, the only outlet for its waters being at Robertsbridge, whence they are discharged into the Rother. A comparatively small depression would convert the lower part of this valley into a small bay communicating with the sea by the valley of the Rother. It would seem probable that in the gradual rise of the land it had formerly existed under that form, and that a great part of the denudation, to which its actual form is probably in a great measure due, was thus effected. Its western extremity is bounded by the high land which is continued southward from Frant by Rotherfield to the west of Heathfield Park, the point to which I traced the Brightling anticlinal line. This transverse high land forms a watershed, from the highest points of which the water descends on the one side through the valley just described to be discharged into the sea by the Rother, and on the other to the Ouse, which passes by Lewes and discharges itself at Newhaven. It does not however assume the character of a transverse *ridge,* its general elevation being much the same as the western extremities of the Brightling, Wadhurst, and Frant Hills on the one hand, and considerably less than that of Crowborough on the other. The Brightling anticlinal line seems to lose all its distinctness when it meets this high land.

Crowborough Anticlinal Line.—The elevated range including Ashdown Forest on the east and St. Leonards Forest on the west manifestly constitutes the central ridge of the middle portion of the Wealden district. It is clearly an anticlinal elevation, though it seems difficult to determine with perfect accuracy the position of the anticlinal line. On the northern side of Ashdown Forest there is a gradual but small continuous rise of the beds towards the summit; and on the south side I traced a much more rapid and continuous dip to the south from near Crowborough Gate to High Hurst Wood, two miles south of the former place. In considerable quarries at the latter place the dip was about 15°. The surface nearer the summit of the Forest is occupied by loose sand, which affords no means of observing the dip. There cannot however be much error in concluding that the anticlinal line passes near to Crowborough Beacon.

The above observations were made in an excursion from Tunbridge Wells to Crowborough. I also crossed this cenfral elevation from Cuckfield to East Grinsted by Balcombe. The dip at the cutting of the Brighton railroad near the last-mentioned place was considerable, and to the north, nor could I detect any indications of southerly dip in crossing Tilgate Forest. From this it appeared probable that the position of the anticlinal line was not north of Balcombe, nor can it certainly be far south of that place, as shown by evidence which I shall speak of shortly.

Of the position of this line between Crowborough Beacon and Balcombe, I have no evidence, but the general continuity of the line between these points is rendered almost certain by the general structure of this part of the district. We may conclude therefore that it here runs almost exactly east and west, and we observe that if it be continued easterly, it precisely coincides with the Wadhurst line. These two lines may therefore be regarded as continuations of one and the same line.

When I thus speak of the unity and continuity of the line between Crowborough and Balcombe, and to the west of the latter place, I am tacitly referring the formation of the Ashdown and St. Leonards ridge to the existence of a single anticlinal line, or (speaking with reference to my theoretical views) of a single longitudinal fissure. It is very possible however that this characteristic ridge may be due to the original and simultaneous formation of several longitudinal fissures, so near to each other, that we are unable to distinguish their separate effects by the outward structure of the elevation. Still such a system of lines, occupying but a small transversal space (as in the present instance), may in descriptive language be spoken of as a single line, and we may still assert the probable identity of this system and the Wadhurst line as in the preceding paragraph.

On the south of Balcombe and between that place and Cuckfield is an east and west valley which forms a distinct feature in that neighbourhood, and of which the length and direction are marked on the Ordnance Map by the course of a small stream, one of those which, by their confluence, ultimately form the river Ouse. In descending into this valley on the northern side, by Slaugham Park, the beds are observed to dip southward with the hill, which shows that the Crowborough line must pass to the north of the Park, agreeing with the direction previously assigned to it. This direction, continued westward, would pass very near Horsham, but that neighbourhood presents no external indications of disturbance, the strata being very nearly horizontal. I examined the quarries near Warnham, at Theall near Slinfold, three miles west of Horsham, at Stammerham, two miles south-west of it, and at Tower Hill near Horsham. In all these places there was scarcely a sensible deviation from perfect horizontality*. There was no evidence of the continuation of any distinct anticlinal line west of St. Leonards Forest.

Cuckfield Line.—On the south of the valley just mentioned as passing between Balcombe and Cuckfield is a small elevated range, sufficiently determinate to give to the valley which it bounds a perfectly distinct character. It is a subordinate

* Dr. Mantell has remarked, that "the dip of the strata around Horsham and Tilgate Forest is exceedingly variable; the general inclination is towards the S.E." He also states that the beds in the Forest are nearly horizontal. The fact is, that all around Horsham the beds are so nearly horizontal, that I think it impossible to assign to them any prevailing dip. In such a case the slightest local cause might determine the existing small dip in each locality.

anticlinal ridge. I found distinct evidence of a northerly dip in descending into the valley along the London road from Cuckfield. Similar evidence is found in the quarries near Cuckfield. On the south side of this hill the general southerly dip of the district commences. I obtained also the most decisive evidence of the continuation of this line between two and three miles east of Cuckfield, at the cutting for the Brighton railroad, which being there transverse to the anticlinal line, exhibited it with great distinctness. The dip to the north at this point could not be much less than 15°. The line appeared to run exactly east and west. It is probably co-extensive at least with the valley to the north of it, extending three miles west of Cuckfield. How far it may extend to the east beyond the railroad, I had not the means of determining. I detected no evidence of it in crossing the general central ridge from Uckfield to East Grinsted.

I may here remark, that in passing along the London and Lewes road, I observed distinct evidence of anticlinal arrangement of the beds close to Uckfield on the south of the town, the strike being east and west. If the Brightling line were continued, it would pass very near this point. I am far from insisting on this as any evidence of the continuation of that line westward of Heathfield Park. It is perhaps more probable that the position of the beds near Uckfield is due to one of those undulations which, although of comparatively small extent, still follow the general law of those which, on a larger scale, are designated as anticlinal elevations. A more detailed examination of the district would probably detect many such minor anticlinals; nor would such an investigation be without its interest and importance, because the greater the number of minor phænomena which can be comprised in our generalizations, the stronger becomes the proof of the truth of the laws established by observation, and of the theories which distinctly deduce such laws from the operation of physical causes. Such detailed research however belongs peculiarly to the province of the local geologist, by whom alone we can hope to see it carried to the extent which the actual state of theory demands.

Before we proceed with the description of other anticlinal lines, it may be well to direct attention to the relations existing between the external configuration of that portion of the district already considered, and its internal structure. The Battle and Brightling ridges, two of the most characteristic, have manifestly originated, as we have seen, in the formation of the anticlinal lines with which they coincide; and it is equally evident that the valley between the Brightling and the Wadhurst line has owed its origin to the formation of the intermediate synclinal line. This arrangement of the beds would necessarily guide more or less the action of the denuding causes to which the complete formation of the valley must be referred. This valley, as I have shown, is bounded on the west by the high land in the neighbourhood of Rotherfield, where there appears to be no considerable

inclination of the strata; while farther westward the elevation of Ashdown Forest has given a considerable and continuous declination of the strata to the south, with which the surface of the country is there in accordance. The actual drainage of the south side of the central ridge from Rotherfield to St. Leonards Forest appears to have originated in this continuous descent of the beds from Ashdown, by which an opening was afforded to the water from the western part of the range, while the Cuckfield anticlinal ridge presented a barrier to their southerly progress. Finally, the configuration of the surface between the ridge just mentioned and the central one is manifestly due to the internal structure, with which also the general descent of the surface to the south from the Cuckfield ridge is in perfect accordance.

Frant Line.—About three miles north of the Wadhurst anticlinal line is a range of hill, extending from Etheridge Park on the west, by Frant, nearly to Lamberhurst on the east. In ascending the hill from Tunbridge Wells by Frant, the dip is small but distinctly to the south, and therefore opposite to the general dip on this side the central range. A new cut in the great road also immediately south of Lamberhurst exhibits the section of an anticlinal line with rapid dips. These observations have convinced me that this range (which forms a marked feature in the country) originated in a curvature of the strata, but such that the deviation from horizontality had not been very considerable, except near Lamberhurst. The prominent feature which the range presents to the north, is probably more due to the denudation of the valley below than to the elevation of the hill. Still both analogy and direct evidence (as far as it extends) indicate the origin I have assigned to it. It will be observed that it preserves an exact parallelism with the Wadhurst line. All traces of it appear to be lost in the transverse high land already mentioned as passing by Frant and Rotherfield.

Bidborough Hill.—This hill is about three miles south of Tunbridge. The road from that place to Tunbridge Wells affords a good section, exhibiting the upper beds of the Hastings sand rising rapidly from beneath the Weald clay, which approaches the foot of the hill on the north side. There must necessarily be an exactly similar rise of the beds along the north side of the hill further to the west, since the beds of the Hastings sand on the side and summit of the ridge rise much above the level of the upper surface of the Weald clay in the valley. On the south side of the hill I could make no good observations of the dip except near Southborough, where the beds are nearly horizontal. More westward there were indications of a considerable dip to the south, which seems probable also from the external form of the hill. I cannot however assert such to be the case from good observations. The western extremity of the hill is bounded by the transverse valley of the Medway; the Tunbridge road passes over its eastern extremity. This may be considered as a line of flexure rather than an anticlinal line.

Brenchley Hill.—This hill is situated about five miles nearly east of Bidborough Hill, to which it is exactly similar, except that it affords more distinct evidence of its being strictly an anticlinal ridge. East of the castle I found opposite dips of nearly 20° to the east of north and about 16° to the south, and so near to each other as to determine accurately the position of the anticlinal line. It there lies a little south of the summit of the ridge.

Brenchley and Bidborough Line.—Bidborough and Brenchley Hills are connected by a range which overlooks the valley occupied by the Weald clay, and is formed by the comparatively rapid rise of the beds of the Hastings sand from beneath the clay. It diminishes in height (probably by denudation) as it approaches the eastern extremity of Bidborough Hill, from which it is separated by an ill-defined transverse valley. A distinct line of flexure thus connects the two hills above mentioned, though the evidence may be somewhat less forcible than it is in those two striking localities. The line of curvature is continued in an exactly similar manner to the west of Bidborough, but becomes less distinct as we proceed westward, and loses all determinate character north of East Grinsted. It dies away also in the same manner at the other extremity east of Brenchley Hill.

Transverse Valleys and Fractures of the Central Ridge.—It will be observed that the continuity of the range just described is broken in three places, at Penshurst by the valley of the Medway, between Bidborough and Brenchley, and again east of Brenchley Hill by the valley before mentioned, along which a small stream rising at the foot of Frant Hill and passing by Lamberhurst finds its way to the Medway. The first is the most remarkable of these transverse valleys.

I have already spoken of the watershed formed by the transverse high land which passes by Rotherfield and Frant; and if we proceed northward from the latter place along the Tunbridge road, we find (as shown by the map) that the streams which rise along that line on the right run to the east, and those on the left run westward, so that the watershed is continued northward as far as the valley of the Weald clay, notwithstanding the great alteration in the external surface produced by denudation to the north of Frant Hill. The Medway is formed by the confluence, about Ashurst, of the streams which thus flow westward, with others running principally from west to east along longitudinal valleys. From this point it takes its course by Penshurst directly through the longitudinal range above described. If this transverse break in the range were now filled up, a lake of considerable area would be formed in the valley of the Medway, with branches ramifying along the different valleys which communicate with it. Supposing such a barrier to have once existed, in this and similar cases which may hereafter be considered, the point to which I would immediately direct attention is the evidence which may enable us to judge how far the destruction of the barrier may have been facilitated by the previous existence of a transverse fracture.

It is probable that such a fracture, when of considerable magnitude, would frequently be attended with considerable irregularity in the position of the beds immediately contiguous to it. Such however would not necessarily be the case; and we may doubtless assert the converse proposition as far more generally true; viz. that great irregularity of elevation will be attended with transverse fracture. Consequently, while a great and irregular inclination of the beds at any transverse section of a longitudinal range almost necessarily affords evidence of transverse fracture, the absence of such irregularity will be no proof of the non-existence of such dislocation. This conclusion is abundantly corroborated by the phænomena of the mining districts, where the evidence on such points is so much more determinate than in those in which the observations are merely superficial.

This irregular disturbance of the strata is remarkable along the sides of the transverse valley of the Medway. Near a spot termed Nashes on the Ordnance Map, the dip was between 40° and 50° to the north; and at a point on the opposite side of the river, and about equidistant from it, I estimated the dip at about 30° south-east. At other points the disturbance was equally great and irregular. It is well seen in the large quarries south of Ashour, where the dip is nearly 20° to the north-east, which is perfectly anomalous considered with reference to that of the general elevation. These facts leave no doubt, in my opinion, of the original existence of a large transverse fracture which has determined the position of the present transverse valley, and facilitated its formation by aqueous agency.

I found similar evidence, though not perhaps equally conclusive, near the transverse valley marked by the course of the river from Lamberhurst to the east of Brenchley Hill. I have already noticed the evidence of an anticlinal line at Lamberhurst. The disturbance there is very considerable, as it is likewise at a point on the opposite side of the valley and nearly equidistant from it, in the large quarries west of Bedgbury Park, as already noticed, where the dip is between 20° and 30°. Goudhurst is situated on a hill which borders the valley on the east, and forms a prominent feature in this neighbourhood. In ascending it from the south by the road which enters the town, we recognise its origin in a great disturbance, which has given a dip to the beds of about 40° to the south. The disturbance appears to be local and irregular; for on the north-east side of the hill the dip appeared (though not very distinctly) to be considerable and to the north-east; and about Iden Green (a mile and a half to the east) no indications of disturbance were visible, the beds being there sensibly horizontal, as well as about Cranbrook, a fact already noticed. Hence I conclude Goudhurst Hill to have been due to one of those irregular disturbances which indicate transverse fracture. Also about Winchet Hill, the point on the east side of the valley exactly opposite to the eastern extremity of Brenchley Hill, I observed considerable irregularity of disturbance.

These circumstances combined afford strong evidence of the valley in question having originated in a transverse fissure.

I shall now proceed to the western and south-western parts of the district.

I have already described the general horizontality of the beds near Horsham, and the consequent absence of any determinate anticlinal *line*. Still the general configuration of the district shows distinctly the continuation of the anticlinal *elevation*. The greensand of Hind Head for instance is much higher than the same beds at those points north and south of that hill where they pass under the chalk escarpments; but this greater elevation being principally acquired soon after emergence from beneath the chalk, the central portion is left nearly horizontal. This relative elevation is also in great measure lost still further to the west by the gradual westward declination of the beds; and therefore, when we arrive at the chalk on the west of the general denudation, it becomes still more difficult to assign any determinate position to a distinct anticlinal line. Mr. Martin however appears to have recognized, in an east and west valley near Haslemere, some evidence of its continuance along that valley, a position which very well accords with the general elevation, and also with the westerly prolongation of the Hastings sands.

Greenhurst Anticlinal Line.—This line, running near and parallel to the South Downs, is one of the most important geological features in the south-western portion of the district. It has already been described in detail by Mr. Martin. The evidence of this line, as pointed out to me by that gentleman, is perfectly clear from the chalk at Piecomb on the east to Coldwaltham Park (south-west of Pulborough) on the west. It will be immediately recognized on the map.

Pulborough Line of Flexure.—About two miles to the north of this line and parallel to it, we recognize a well-marked line of flexure passing close above the village of Pulborough. The annexed diagram represents the section from the chalk escarpment to the Weald clay, in a direction nearly north and south, and passing by Wiggonholt Common and Pulborough.

2.



4. Chalk and Upper Greensand.
3. Gault.
2′. Lower Greensand, lower beds.
2. Lower Greensand, upper beds.
1. Weald Clay.

The Greenhurst line meets the section at A, and the line of flexure at B.

This line of flexure does not extend far to the east of Pulborough. On the west of that place it is well defined near Stopham and Fittleworth.

Midhurst Line of Flexure.—A line exactly similar to the one just described, and sufficiently well defined, passes by Sellham and Midhurst to Trotton Common. A north and south section, however, across this line differs from the above section in the absence of the anticlinal disposition of the beds there represented at (A). The beds rise to the line of flexure (B) directly from the chalk.

This line ranges exactly with the Pulborough line. They both appear to me to belong in fact to the same line, as represented in the map. Mr. Martin however appears to think, that what I have termed the Midhurst line is a continuation of the Greenhurst anticlinal line, which he supposes to take a north-westerly direction from the point where I have considered it to terminate, nearly in the direction of the river, to Sellham. There cannot, I conceive, be any very positive evidence of the junction of these two lines, and therefore I have preferred the view above given respecting them. The difference however between this view and Mr. Martin's is of no importance whatever.

Lewes Anticlinal Line.—In the cliffs and chalk-pits north-west of Lewes, and in those north-east of it on the opposite side of the river, the upper chalk with flints dips with a rapidity which would, at a comparatively short distance to the south, carry the upper beds of the chalk down to the level of the bed of the river, whereas the chalk hills in that direction, on the opposite side of the chalk valley in which Kingston and Falmer are situated, are nearly as high as the escarpment north-west of Lewes. There must necessarily therefore be either a fault, or a rise of the beds to the north from a synclinal line, by which the chalk about Kingston is brought up to its actual elevation. The complete explanation is given by the natural section on the opposite side of the river near Southerham. The rapid ascent of the beds to the south is there beautifully exhibited. The synclinal line passes into the cliff just about the coombe-like valley (marked in the Ordnance Map) immediately north of Southerham, in the insulated chalk hill east of Lewes. It is doubtless connected with the formation of that valley. The southerly ascent of the beds is seen very distinctly till they meet the valley between the hill just mentioned and the general chalk escarpment on the south of it, where the regular dip to the south is again resumed. The anticlinal line must therefore run along this valley. Mr. Martin has detected farther indications of its continuation to the east, and, for the reason above stated, it is certain that it strikes into the chalk on the west of Lewes. The exact coincidence of the direction of this line with that of the Greenhurst line renders it highly probable that the one is a prolongation of the other*.

* Dr. Mantell observed these phænomena in the immediate neighbourhood of Lewes, and has given a section of the chalk cliffs on the east side of the river opposite to the town, in his 'Geology of the South-east of England,' p. 352.

At Piecomb and south-east of Lewes, (the points at which the Greenhurst and Lewes lines of elevation respectively strike into the projecting chalk mass,) there are two large coombe-like valleys which are worthy of remark, as indicating in the most unequivocal manner, the influence of a line of dislocation in aiding and guiding the operation of denuding causes. Had the action of these causes continued, it is easy to see how, as far as the dislocations may proceed, the projecting chalk between Lewes and Piecomb would have gradually disappeared as much by the process thus indicated on its flanks as by the effect produced on the general front escarpment. From Piecomb to a point directly south of Petworth, as well as to the east of the insulated chalk hill at Lewes, this operation has been completed, which has probably been owing to the more decided character of the dislocation along those portions of the anticlinal lines than between Lewes and Piecomb. I have stated my reasons for doubting the actual prolongation of the Greenhurst line west of the projecting chalk escarpment directly south of Petworth. This projection is probably due to the feebler influence of the dislocation as it approached that point. The two coombe-like valleys above mentioned may afford a useful analogy in forming our conclusions in some other cases to be hereafter described.

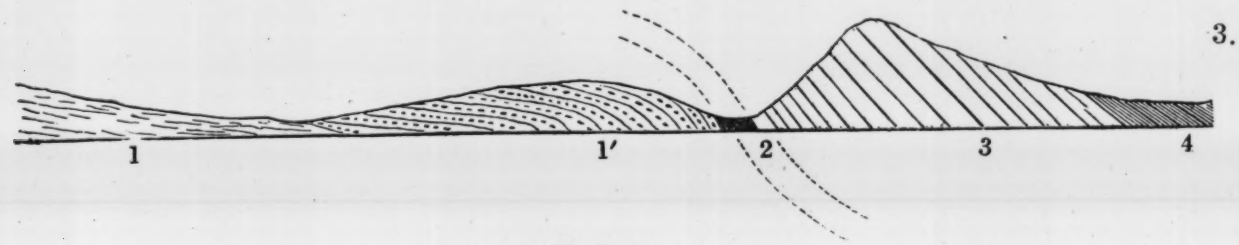
Transverse Valleys near the Greenhurst Line.—On the north-west of Pulborough the river Arun makes its way through the lofty escarpment of the greensand, as described some years ago by Mr. Martin, who also pointed out to me a remarkable and anomalous dislocation at the point immediately east of the transverse valley where the river first penetrates the escarpment. The beds dip north-west at an angle of about 30°, whereas in the vicinity there is a very regular dip to the south. This has been justly attributed I think by Mr. Martin to the transverse fracture in which we conceive the valley to have originated. The evidence is precisely similar to that already adduced with respect to the transverse breaks in the Bidborough range. It will be remarked too, that at Lodsworth, west of Petworth, one of the tributary streams to the Arun penetrates the greensand escarpment, in the manner above described. A small stream also descends down a deep valley east of Petworth from the upper part of the greensand range, and Mr. Martin informed me that there exists evidence of this valley having in like manner originated in a cross fracture.

I would also here direct attention to the manner in which the chalk ridge is traversed by the Arun, the Adur, the Ouse and the Cuckmare, circumstances to which I shall again allude in the sequel.

I shall now proceed to the north-western part of the district.

The Farnham, Guildford, Dorking and Godstone Line of Flexure.—The most remarkable part of this line is the chalk hill called the Hog's Back, extending from Guildford to a point within about two miles of Farnham, where it ceases somewhat abruptly. The dip at Guildford is considerable, but increases as we proceed westerly

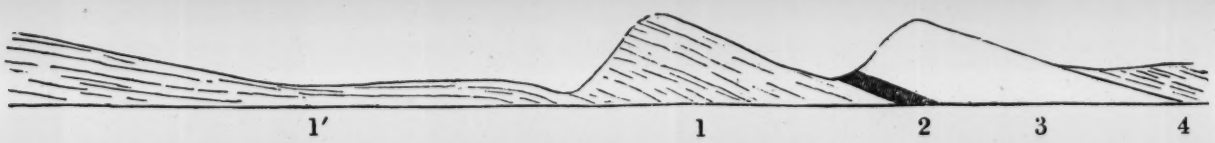
till, about Seal, it amounts to 70° or 80°, being everywhere exactly north. This dip carries the chalk rapidly down under the tertiary beds, leaving a narrow and lofty ridge of chalk. The basseting edge of the gault occupies a narrow strip at the foot of the escarpment, but the upper beds of the lower greensand occupy a far larger proportionate surface. This is owing to the fact of their inclination being very much less than that of the chalk, as represented in the annexed diagram.



4. Tertiaries.
3. Chalk.
2. Gault.
1, 1′. Lower Greensand.

The section through Crookbury Hill is similar to the one here given, except that the lower greensand rises to a greater height than in the instance before us. This elevation shows that the beds of that formation must have a considerable dip from thence to the Hog's Back ; and this dip, though much less than that of the chalk, is considerably greater than that of the greensand beds further south, which would otherwise have occupied a very much smaller space in that direction than they actually occupy. This change in the magnitude of the dip probably takes place near the hill, but I saw no distinct reason to suppose that the hill is anticlinal, as Mr. Martin appears to think it. The same observation will apply I think to the whole of his Pease Marsh anticlinal line, east of the hill in question. The proper line of flexure (as previously defined) from the western extremity of the Hog's Back to the east of Puttenham is unquestionably very near the foot of the escarpment ; and by Guildford, it runs not far south of St. Catherine's Hill, and close under the hill above Shalford, and the prominent point on which Margaret's Chapel is situated. At Guildford the inclination of the chalk, though still very considerable, is much less than it is farther to the west ; but here it is continued without diminution to the first escarpment of greensand, constituting the hills just mentioned. That of Margaret's Chapel attains a higher elevation than the chalk escarpment, as represented in the annexed section, though it is not much more than a quarter of a

SECTION THROUGH MARGARET'S CHAPEL HILL, NEAR GUILDFORD.

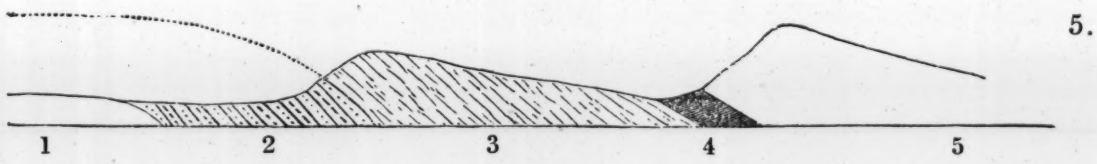


4. Tertiaries.
3. Chalk.
2. Gault.
1, 1.′ Lower Greensand.

mile from its foot. The sand emerges from beneath the chalk in the same manner by Albury, Shiere and Wotton, though, as we proceed easterly, the first escarpment of greensand (at the foot of which the river runs by Albury) becomes less determinate. On the south of this line I could find no distinct indications of southerly dip; on the contrary, all my observations indicated a gradual rise of the beds from the foot of the first to the summit of the second escarpment of greensand along Leith Hill and Hurtwood Common. I therefore concluded that this was, throughout the whole of the range above mentioned, an extremely well-defined line of flexure, without being anticlinal. Mr. Martin regards the part of the line east of Guildford as a continuation of his Pease Marsh line*.

As we proceed westward of Gomshall, this line is perhaps somewhat less distinct. Immediately south of Dorking, however, it is well marked in Berry Hill, on the south side of which the Weald clay is brought to the surface, dipping rapidly to

SECTION THROUGH DORKING.



5. Chalk.
4. Gault.
3. Lower Greensand.
2. Weald Clay.
1. Hastings Sand.

the north. Still I found no indications of an anticlinal arrangement. In proceeding across the small valley in which Berry Hill Park is situated, and thence up the hill on the road to Leith Hill, we find the junction of the lower greensand and Weald clay at a considerably greater elevation than at Berry Hill. From the latter to the former point, the Weald clay would probably rise by its general inclination in Leith Hill, which is much smaller than that with which it rises up to Berry Hill.

The continuation of this line is also recognized along the range of hill extending from Park Hill, Reigate, by Bletchingley to Tilburstow Hill, south of Godalming. The Weald clay appears at a considerable elevation on the south side of the latter hill. If the inclination with which it rises to that point were continued south of it, the width of the surface occupied by this formation would probably not exceed three times its thickness. The actual width is however about four miles. There must consequently be a great change of inclination immediately to the south of

* The difference between my representation of these phænomena and Mr. Martin's arises merely from my recognizing the *line of flexure* as that which ought to be especially noted, rather than that which he considers as marked by a small degree of anticlinal arrangement.

Tilburstow Hill, which distinctly proves the continuation of the line of elevation up to that point*.

Evidence of Transverse Fractures between Farnham and Godstone.—Leith Hill is the highest hill in the whole district, being 993 feet above the level of the sea. The Weald clay in its south escarpment rises to the height of 200 or 300 feet above the valley at its foot. The dip appears to be generally regular from the summit to the first escarpment of greensand already described. It presents to us some important indications of transverse fracture.

At the south-east corner of the hill, near the small hamlet of Cold Harbour, a great local disturbance has evidently taken place, and is shown by the position of the beds in the side of the hill south-west of the hamlet and in the quarries near it. The direction of the fracture is also indicated by the deep-cut valley running northward from the village. The whole of this picturesque spot, as we descend from the summit of the hill by Kittlands, is strongly indicative of local disturbance. I attribute these appearances to a transverse fracture running north and south along the above-mentioned valley. The indentation in the face of the escarpment on the south, exactly opposite the deep-cut valley on the north, indicates the manner in which the denuding agents have been guided and aided in their work by the fracture; and we easily conceive how, if their operation had been continued for a comparatively short time longer, the eastern extremity of this hill would have become an insulated mass, like the chalk hill on the east side of Lewes.

Immediately to the west of Leith Hill, we also observe a deep indentation in the face of the hill (distinctly marked on the Ordnance Map), which forms one of those coombe-like valleys before noticed at Piecomb and Lewes, the origin of which I refer to the existence of a cross fracture operating precisely as the longitudinal one has undoubtedly operated at those places. There is likewise another indentation of the same kind a little further to the west, as shown also by the map; and an exactly similar case also presents itself at Hascombe in the escarpment of the greensand south of Godalming. In all these instances there is not merely an indentation in the face of the hill, but a narrow valley has been formed, of greater or less depth, through the top of the ridge, and is continued down the regular slope of the hill on the opposite side. In each of these transverse valleys, and in others of the same kind, there exists a perennial spring a little below the highest point of the valley on the sloping side of the hill, and in general also a correspond-

* Dr. Mantell recognizes a *fault* in this hill, and I have no doubt that such is the case, and that it probably extends some distance westward. It is very possible that this long *line of flexure* may in several places become a *line of fault*, but the distinction is immaterial as regards my own theoretical views in this district. They are equally *lines of elevation*.

ing one in the escarpment. I have observed the temperature of a considerable number of springs of this description, and have found it, at different times of the year, to be uniformly about 51° or 52° Fahr. These springs seem strongly confirmative of the existence of transverse dislocations, of which they would be almost the necessary consequences.

Transverse River-courses through the Greensand Escarpment.—In the transverse valleys just described, we may probably recognise the earliest stage in the formation of those large transverse valleys which have resulted from the removal in such places of the whole escarpment of the greensand, and through which the transverse drainage of the district takes place. One of these is opposite Guildford, and another near Dorking. The wider these valleys are, the less likely are they to afford present indications of any transverse dislocations in which they may have originated. In neither of these cases have I been able to recognise direct proofs of such origin. Our conclusions respecting them can only, therefore, rest on analogy.

There is also another curious case of a transverse river-course, opposite the western extremity of the Hog's Back, where the western branch of the Wey, instead of pursuing what might appear its natural course at the foot of that hill, cuts directly through the greensand ridge west of Cooksbury Hill. It seems to have an obvious connexion with the change of structure which is observable between the chalk ridge just mentioned and Farnham. I have already stated that the dip towards the western end of that ridge is not less than 70° or 80°, whereas at Farnham it is not more perhaps than about 10°. This change accounts for the sudden termination of the ridge, and indicates moreover a transverse curvature, such as must almost necessarily be accompanied by a transverse fracture, which, continued in a direction exactly south from thence, would account for the actual and apparently anomalous direction of the river-course as above described.

West of the supposed transverse fracture just mentioned, the Guildford line loses its distinct character. I doubt its continuance much to the west of Farnham. Near that place I believe considerable disturbance is indicated by subterranean water-courses, but I could detect no conclusive external evidence of a line of curvature or anticlinal line beyond that place. Mr. Martin's Pease Marsh line, however, somewhat south of the former, seems, as it approaches the chalk westward, to assume a more determinate character than I conceive it to have nearer Guildford. Towards the east I have shown that the Guildford line extends to Tilburstow Hill. Immediately east of that hill is another break through the greensand escarpment, to the east of which we find a line of elevation, which I shall now proceed to describe.

Seven Oaks Line.—This line was first noticed by Dr. Fitton in his memoir "On the Strata below the Chalk." He traced it from Montreal Park to a point between

Westerham and Limpsfield. I also found indications of it nearly as far to the east as Seal. In some places (as at Dry Hill Farm, west of Sundridge) it assumes a distinct anticlinal character; at other places it appears to be a line of curvature, the beds rising rapidly from the north, and being continued with a gradual ascent to the greensand escarpment. I did not examine the country in the immediate vicinity of Limpsfield, to ascertain whether this line was a continuation of the Guildford and Godstone line or not. On that account, as well as from the circumstances of its assuming a somewhat different character and deviating in some degree from the direction of that line, I have given it a distinct appellation. They both probably belong strictly to the same continuous line of dislocation.

From the eastern extremity of this line to the coast at Folkstone, I believe there is no distinct analogous line of elevation, either along the greensand escarpment, or between it and the escarpment of the chalk. The beds rise with a gradual and easy inclination from beneath the chalk, and present no distinct evidence, so far as I have been able to detect, of any determinate line of elevation.

' *Transverse Valleys of the Seven Oaks Range of Greensand.*—In this range are several transverse valleys similar to those already described in the Leith Hill range. One of the best-defined is that which descends from the escarpment by French Street and through Hill Park east of Westerham. It is marked by a strong spring in the escarpment, and from French Street a rivulet descends to the north along the valley. I can feel no doubt of the origin of this valley having been due to a transverse fracture. We have a similar case again at Ide Hill, (about two miles to the east of the former,) though the valley is not so well-marked a feature as in the former instance. We have, however, the strong spring in the escarpment, with decided evidence of considerable local disturbance about the hill. A third case is found in a narrow valley which descends from Whitley Mill (about two miles south-west of Seven Oaks) immediately to the east of Riverhead. The disturbances along this valley demonstrate its origin to have been in a dislocation. The stream which works the mill originates almost entirely in the copious spring just above it, and in the escarpment at Everlands we find the corresponding spring. This has evidently been a strong fracture, and we may observe that its direction exactly ranges with that of the valley along which the river Darent penetrates the chalk.

Maidstone, Ashford and Folkstone Range of Greensand.—On the east of Seven Oaks there is a break in the greensand escarpment, beyond which that formation occupies a considerably wider space opposite the entrance of the Medway into the chalk hills. The smallness of the general dip corresponds to this increase of width, and the phænomena of elevation appear to be less marked and interesting here than in the greater part of the area occupied by the greensand. East of the Medway

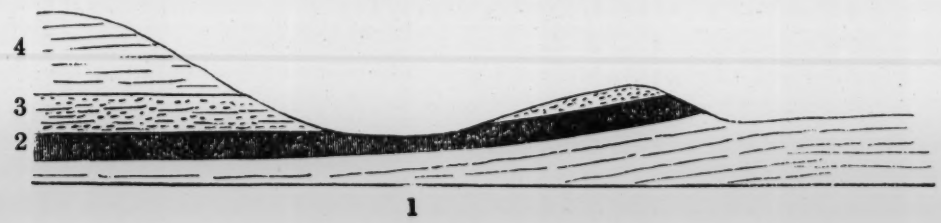
the escarpment becomes extremely bold and abrupt till we come beyond Pluckley, a village five or six miles from Ashford. About Sutton and Ulcomb it begins to approximate to the chalk escarpment, and its general dip must be somewhat greater. Opposite Ashford we find another great break in the range, which, further south, no longer preserves by its elevation the distinct character which it generally possesses.

The springs along this escarpment are not nearly so frequent as in those of Leith Hill and Seven Oaks, where the indications of disturbance are much greater; and we may particularly remark, that between the Medway and Sutton Valence, the Ordnance Map does not indicate the existence of a single rivulet flowing from the escarpment, and resembling those always formed elsewhere by the springs I have described. Now this part of the escarpment, from its altitude and verticality, would be particularly favourable to the formation of springs in cases where the water, arrested in its descent from the upper surface by some impervious stratum, would be compelled to seek a horizontal outlet, probably that which the nearest valley or escarpment would afford. Such springs however seldom occur in escarpments *from* which there is any considerable dip; and on this account the escarpments previously mentioned would be less favourable to the production of springs than that now spoken of. The comparative absence of springs in this escarpment is probably due to an absence of those dislocations in which perennial springs so frequently originate. This conclusion is in perfect harmony with the undisturbed character of this portion of the district. In the escarpment east of Sutton there are two or three large springs which I attribute to fractures; there is also reason to believe that the disturbance has there been somewhat greater.

River-courses through the Chalk Escarpment.—One of the most curious circumstances connected with the geological structure of the Wealden district is its transverse drainage through the apparently insurmountable barrier of the surrounding chalk hills. The river-courses through these hills are far more striking than similar instances already mentioned in the interior of the district, because, in the first place, the barrier broken through is of far greater strength and massiveness, and secondly, the continuous lateral longitudinal valleys seem to present scarcely the smallest impediment to a totally different drainage, by which the whole water of the district might have been carried along those valleys under the chalk escarpment, or that of the greensand, and discharged into the channel by Folkstone or Beachy Head. The most obvious solution of the difficulty which the existence of the transverse river-courses under such circumstances presents to us, is in the hypothesis of their having originated, as in other cases, in transverse dislocation, and I have been desirous of verifying the truth of this hypothesis by the discovery of indications of disruption along the transverse valleys through the chalk. I have not, however, in these instances been very successful. The amount of the

positive evidence of facts is not great. The point at which the river at Dorking breaks through the chalk escarpment is directly opposite the extremity of Leith Hill, which has obviously been a point of considerable disturbance, and it is highly probable that any transverse fracture there might also pass through the chalk. Near Seven Oaks, I have already shown that a well-defined line of fracture in the greensand would, if produced, pass along the river-course through the chalk. The course of the Arun through the chalk is along the direction of the valley by which it cuts through the greensand, and which affords direct evidence of dislocation. The course of the Ouse at Lewes seems also evidently connected with the great disturbance which has there taken place. But one of the best indications perhaps of the connexion between transverse valleys and dislocation in the chalk is afforded by the well-marked valley along which the road from Godstone to London passes. The state of internal dislocation of the chalk is shown by the occasional bursting forth of a copious stream which takes its course northward down the valley. This does not occur, I believe, more than once in two or three years, and after a more than usually rainy period. I am told that the water possesses some property which renders it very destructive to vegetation.

Another case also, though not comprised within the district with which I am immediately occupied, deserves notice. I allude to the transverse course of the river Medina through the middle of the central ridge of the Isle of Wight. The two parts of the ridge on the east and west respectively of the north and south transverse valley are not in the same line, but are so situated that their anticlinal lines are parallel and about two miles apart. The western portion of the ridge swells out to the north on the west of the cross valley to meet the extremity of the other portion, the dip of this connecting portion of the range being generally about north-west and south-east, or in some parts more easterly and westerly. The annexed diagram represents an east and west section of the valley of the Medina near Rookley, and very nearly in the direction of the more southerly anticlinal line. It presents a north and south line of flexure which must almost necessarily be ac-



4. Chalk.
3. Upper Greensand.
2. Gault.
1. Lower Greensand.

companied by a corresponding north and south fracture, in which I conceive the valley to have originated.

Independently of such evidence as the above, the opinion that river-courses through the chalk escarpment have originated in transverse fissures must rest on analogy, or more especially on the degree in which the hypothesis harmonizes with that general theory which may be recognised as best accounting for the general phænomena of elevation. I shall again refer to the same point in the concluding section of this memoir.

The Bas Boulonnais.

The denudation of the Bas Boulonnais has laid bare certain portions of the oolitic series, which, together with the cretaceous beds, were first described by Dr. Fitton and subsequently in greater detail by M. Roget, to whose work I am indebted for much information. I shall find it necessary to repeat in some measure what had been previously observed by these gentlemen respecting the superficial range of the different beds of the district, in order to convey a more distinct conception of its *geological structure*.

At Wissant the gault is observed to emerge at a slight inclination, but is again immediately lost under the accumulations of sand (*les dunes*), extending nearly two miles along the coast. To the south of these dunes the Kimmeridge clay commences and occupies the whole range of coast, with the exception of some other dunes at the mouths of the rivers, till we arrive at those which extend along the coast from the southern part of this district for many miles. In proceeding eastward from the coast, we find the coral rag and Oxford clay brought to the surface by a very small rise of the strata in that direction. On the south of the river which falls into the sea at Ambleteuse, the Oxford clay is the lowest bed which is thus exhibited (Diagram No. 26.)*. On the north of that river the same clay is brought up in like manner, but by a rather greater inclination of the strata, and consequently at a smaller distance from the coast (Diagram No. 25.). An inferior portion of the oolites also here emerges from beneath the Oxford clay, and reposes immediately and unconformably on a portion of the carboniferous series consisting of mountain limestone and interpolated beds of coal.

This last circumstance exhibits that great discontinuity in the process of deposition, so generally recognised in this part of the world, which took place after the formation of the carboniferous series. Another important instance of a similar kind is also not less clearly shown in this district than in the southern coast of England, in the entire unconformity of the chalk, gault, and greensand with the beds on which they repose. To the west of the Calais road through Marquise, the lower of these beds appear to come in contact with the Oxford clay. Immediately to the east of that road the mountain limestone presents itself, and to the north of

* These diagrams of the Bas Boulonnais are appended to the memoir, and will be found in pages 47, 48.

it the highly inclined beds of still lower formations, on which the chalk itself seems immediately to repose. In the north-east corner of the district, the cretaceous system overlies the upturned edges of the mountain limestone with its beds of coal; till we come to the south of the river which bounds the older formations, where the lower greensand is found to repose on the Oxford clay along the whole boundary of the district by Boursin, Colemberg, Henneveux, Brunembert, Lottinghen, and Desvres. To the south-west of the latter place, and at Samer, the greensand lies immediately on the coral rag; and along the southern boundary it reposes also on that formation or on the Kimmeridge clay.

Oxford Clay.—The hill north-west of Marquise, on which the village of Basinghen is situated, presents to the east an escarpment of considerable elevation, the upper part of which is occupied by the Oxford clay, and the lower part by the oolitic beds immediately beneath it (Diagram No. 26.). These latter beds extend a little to the west of the Marquise and Calais road, where they form a thin and unconformable covering to the lower part of the platform formed by the surface of the mountain limestone.

At some distance north of the village, the Basinghen Hill takes a north-westerly direction; and from that point the Oxford clay descends and passes under the upper formations nearer the coast. On the south of Basinghen it likewise descends towards the south and passes beneath the valley of the Ambleteuse river. The coral rag also bassets out on the high ground west of Basinghen, passing down to the above-mentioned valley, and under the Kimmeridge clay which occupies the coast from Ambleteuse to the dunes at Wissant.

On the south of the Ambleteuse river the Oxford clay forms an escarpment similar to that at Basinghen, but is at a greater distance from the coast (Diagram No. 26.). It passes from the east of Wievre Effroy to meet the valley of the Wimereux near Belle. On the south of that valley the high ground is projected eastward beyond Alinctun, where the Oxford clay still rises to the brow of the hill by Henneveux and Brunembert, as far as the Liane. The same formation also occupies the whole of the district east of this line of hill, till it is concealed beneath the unconformable covering of the cretaceous system as previously described. On the south of Brunembert the escarpment takes the westerly direction of the Liane, the upper part being formed of the coral rag and the lower of Oxford clay, the lower part of which probably stretches over the surface of the greater part of the valley comprised between the above escarpment on the north, the forest of Desvres on the west, and the boundary hills on the east and south. Thence it passes under the eminence on which the forest just mentioned is situated, and rises in the hill which still follows the course of the Liane in the south-westerly direction which that river suddenly assumes, till it meets the road from Boulogne to Desvres, near

which after a gradual southerly declination the clay passes entirely under the coral rag.

Coral Rag.—This formation is found to basset regularly in a band of greater or less width on the west of each of the hills above described as having its escarpment formed principally by the Oxford clay. From the point at which that formation entirely disappears (as just stated) beneath the coral rag, the latter occupies the valley of the Liane to a considerable elevation on both sides of the river, till it arrives within about two miles of Boulogne. It passes also under the eminence on which Samer, on the Paris road, is situated, beyond which it is covered up by the lower greensand.

Kimmeridge Clay.—This formation succeeds in ascending order. North of Ambleteuse it occupies a narrow tract along the coast. On the south of the river it extends from the coast by Maninghen to the east of Hesdres, over the high ground which intervenes between the Ambleteuse and the Wimereux rivers. And on the south of the latter it extends in like manner from the coast into the Forêt de Boulogne, and occupies the heights immediately to the north of that part of the valley of the Liane along which runs the Paris road, the sides of the valley itself being occupied by the coral rag, as before stated. The most eastern point to which it proceeds is Samer. The insulated hill on which that place is situated is capped by some of its lower beds, distinctly characterized by the *Gryphæa virgula*, and resting on the coral rag which forms the base of the hill (as already mentioned), and extends to the valley of the Liane. On the south of the Liane it extends from the coast in a similar manner, till the coral rag emerges from beneath it, or it becomes concealed by the unconformable covering of lower greensand.

This formation is best exhibited in the coast section immediately to the north of Boulogne. The lower division consists of a species of blue marl, with not unfrequent hard stony bands, and is for the most part filled with the remains of the *Gryphæa virgula*. The upper portion consists of a similar blue marl, frequently somewhat shaly, and containing the *Gryphæa virgula* in much smaller quantity. It contains however in considerable numbers a *Gryphæa* which appears to me a distinct species, and has not, I think, been yet named. This portion is also characterized by the *Ostrea deltoidea*, of which I never observed a specimen in the lower portion of the formation. These two parts are separated by thick continuous bands of sandstone frequently characterized by large *Trigoniæ* (Diagrams Nos. 27, 28, 30.). They descend to the level of the sea at La Crêche (Diagram No. 28.), and furnish the enormous blocks on the beach at that point. It is by means of these distinct divisions of this formation that we are enabled to make out the geological structure, where most complicated, with a degree of accuracy which would otherwise be unattainable.

Structure of the District near the Coast.—Commencing with the coast section from Boulogne (Diagram No. 28.) and proceeding northward, we observe that the stony bands which separate the two portions of the Kimmeridge clay are brought down from the top of the cliff to the beach, by a rapid curvature of the beds, at La Crêche. These beds then dip beneath the level of the sea, and the cliff, from that place to the mouth of the Wimereux, is composed, in its lower part, of the upper division of the Kimmeridge clay, the higher portion of the cliff consisting of the superincumbent sandstone beds above described. In this part of the cliff there is a considerable dip to the north which carries the upper surface of the Kimmeridge clay below the level of the sea at the dunes at the mouth of the Wimereux. On the north of the dunes, however, the upper division of that formation is found at a considerable altitude. It afterwards descends again with a gentle dip to the north beneath the Ambleteuse dunes. It ranges also to the eastward along the north side of the valley of the Wimereux, where it may be distinctly traced nearly as far as the Calais road, ascending by the gentle eastward rise of the beds nearly to the top of the hill. I identified it at the mouth of the Wimereux and also near the Calais road by the deltoid oyster; and moreover, near to the village of Wimille, the lower bed of Kimmeridge clay is distinctly recognised in the lower part of the valley by the abundance of the *Gryphæa virgula*. Returning to the top of the cliff at La Crêche, we find distinct evidence of the continuance, in a direction parallel to the Wimereux, of the line of flexure of which the section is so beautifully exhibited in the cliff. The junction of the upper sand on the north with the lower Kimmeridge clay on the south, which marks the course of the line, may be distinctly traced close by the fort near La Crêche, to the north of the column of Napoleon, into the upper part of the valley of the little river Denacq. In some part of this range it probably becomes a *line of fault*.

On the north of this line it is easy to trace the upper division of the Kimmeridge clay with the superincumbent upper sand down to the valley of the Wimereux (to which it descends in the same manner as in the cliff) and also to the Denacq. The windmill about three-quarters of a mile from Wimereux, on the Boulogne road, stands on the clay (Diagram No. 29.), which also appears at the little hamlet north of the column, whence it passes northward under the quarries in the upper sand near that spot. In a quarry also near to Wimille, and between the great road and the Denacq, the beds of that formation are found to dip rapidly into the valley. Hence then the upper division of the Kimmeridge clay passes into the bottom of the valley of the Wimereux on its southern side, while on the northern side, as already shown, it occupies nearly the top of the hill. Consequently there must be a very large fault ranging along that valley from the coast to the village of Wimille (Diagram No. 29.).

The top of Mont Lambert is the highest point within a considerable distance of Boulogne. The extensive quarries near its summit are easily recognised as belonging to the upper sand. In descending in any direction we soon arrive at the upper division of the Kimmeridge clay, and along the road to Boulogne the siliceous beds beneath it are distinctly seen. These descend the hill on the north side across the St. Omer road down to the upper part of the valley of the Denacq, already noticed as ranging with the La Crêche line of elevation, where I found them near the upper extremity of the valley abutting directly against the upper division of the Kimmeridge clay (Diagram No. 30.). This distinctly proves the continuation of the La Crêche line up to this point. It probably dies away somewhat east of it.

At the point just mentioned the clay was identified by the oyster shells; and, moreover, I traced it along the brow of the hill on the east of the valley of the Denacq, which shows that a great fault also ranges along the lower part of that valley down to Wimille, since it has been shown that the upper division of the Kimmeridge clay passes down to the bottom of the valley on its western side.

When the clay on the east side of the valley of the Denacq meets the valley of the Wimereux, it ranges along its south side at the same elevation. It also constitutes the hill on the north side of the valley nearly to the summit immediately east of the Calais road; consequently we have no longer the same evidence of a great fault ranging along this valley east of Wimille, as on the west of that place. There are evidences of disturbance, however, on the north side of the valley. South of Maninghen I found the beds in a newly-opened pit dipping very rapidly to the north. About Souvremoulin there were indications of cross fractures, by which the lower beds of the Kimmeridge clay are brought nearer the bottom of the valley than either to the east or west of that place. I have no doubt therefore that the dislocation, in which the valley west of Wimille undoubtedly originated, was continued to the east of that place. It probably dies away towards the upper part of the valley in the same manner as in the La Crêche line.

From the high ground north of the Wimereux, and between the coast and the Calais road, the upper division of the Kimmeridge clay may be traced, gradually descending towards the Ambleteuse valley as in the coast section, the declination of the strata in that direction however being less, as far as I could judge, at points more remote from the coast. At Auxdresselles, the northern extremity of the Ambleteuse dunes, we find some hard siliceous beds rising from beneath the valley, and apparently also from beneath the upper division of the Kimmeridge clay. The portion at the level of the beach being disintegrated by the waves, leaves the shore strewed with enormous blocks, exactly similar to those which are found also on the beach at La Crêche, and they belong, I conceive, to the same bed. North of Aux-

dresselles, the dip, as seen in the cliff, is to the south, which shows the valley to be here formed by a synclinal arrangement of the beds, since on the south of the valley the dip is northerly. The same arrangement is also maintained more to the east, as shown by the section (Diagram No. 30.) of the hill at Basinghen already described. On the east of Marquise the valley is bounded by the older formations, and a transverse section of it is altogether different.

I have already mentioned the general structure of Mont Lambert near Boulogne. The hill appears to have originated in a local disturbance. On the side towards Bainctun, the beds dip very rapidly into the hill, an arrangement of the strata which brings up the coral rag at the foot of the hill, and the Oxford clay in the valley at Bainctun as shown in Diagram No. 27. The general dip of the hill on the western side is small and towards the coast. On the north it has already been stated that the dip is with the general declination of the surface in that direction.

On the south of the Liane there are no indications of distinct lines of elevation.

In the portion of the Bas Boulonnais more remote from the sea, and occupied by the oolites, the indications of elevatory movements are much less sensible than in the tract already described. I was not able there to trace the lines of elevation above described to points more remote from the coast than those above indicated. There is, however, some evidence of a transverse dislocation close to the borders of the chalk near Henneveux, which is perhaps deserving of mention. It has been stated in a former part of this paper, in tracing the course of the Oxford clay, that the hill on which Alinctun is situated projects its eastern escarpment as far east as Henneveux and Brunembert, very near to the opposite chalk escarpment. It appeared to me probable that the Oxford clay dipped with some rapidity to pass under the chalk. This must necessarily be the case if the present difference of elevation between the top of the Oxford clay escarpment and the bottom of that of the chalk was produced by the elevatory movement which took place after the deposition of the oolites. Assuming this to be true, there must here be a transverse line of flexure, such as would almost necessarily be attended by a corresponding dislocation. Such a fracture is indicated by a deep valley which cuts directly across the high plateau of Oxford clay near its eastern extremity. The course of the valley is marked by a small stream which falls into the Liane near the village of Bournonville. It would be extremely difficult to account for it, I conceive, in any other manner. Still, it is possible, though I think improbable, that the surface of the Oxford clay might have been approximately the same as at present before the unconformable deposition of the cretaceous system, in which case its actual configuration may have been due to denudation, and not to elevation.

Structure of the North-eastern Portion of the District.—This is the tract occupied

by the carboniferous and older formations. An account of its structure is in some measure foreign to my present object, since it must be almost entirely independent of the elevatory movement which led to the denudation of the district. I shall only offer one or two remarks on the subject. The surface of this portion of the district forms a rather elevated plateau bounded by the chalk hills on the north, and by the river which runs by Marquise on the south. On the north side the beds dip very rapidly to the south. The surface of the southern boundary is covered up by a thin covering of the unconformable oolites, but in one part I found a clear section of the inferior beds, which showed them dipping very rapidly and regularly to the north. If such be the case along the whole southern boundary (as I think extremely probable), the central portion of these older formations must lie in a synclinal trough. The dip is there very irregular, and generally much less than on the northern boundary, or at the point where I observed it on the southern limit. These facts are easily accounted for by the structure now described.

§ 2. Theory of the Elevation of the District.

The special object of this second section of my memoir is the comparison of the phænomena above described with the conclusions drawn from the theory of elevation as given in the Transactions of the Cambridge Philosophical Society; but I shall also avail myself of this opportunity of developing several points of that theory more in detail, and of offering such elucidations of the whole subject as the example before us may afford. In doing this I shall add somewhat to the mechanical reasoning hitherto employed; but, generally, those parts of the memoir in which we are not engaged in the immediate application of one theory to the district before us, will consist rather of more detailed explanations of fundamental hypotheses and final results, than of the mechanical reasoning, for which I must refer the reader to the memoir just alluded to.

1. In any accurate researches on this subject, based on mechanical principles, some hypotheses must necessarily be made respecting the *constitution of the elevated mass and the action of the elevatory force*. In the memoir above referred to, I have obtained the general results, assuming, for the greater simplicity, the cohesive power of the mass to be uniform throughout, and have then shown in what other cases those results would still be accurately or approximately true. The cohesion may have varied *continuously* according to any law and in any degree, in passing from one point of the mass to another; or it may have varied *discontinuously* along any vertical line within the mass, as for instance, in passing from one hori-

zontal bed to the contiguous one. In these cases the general results will still be accurately true, so far at least as we are now concerned with them. I have also shown what modifications would be produced in the phænomena by the existence of planes or surfaces within the mass, irregular in position and of partial extent, along which the cohesive power may be much smaller than in the immediately contiguous portions of the mass. They may be termed *surfaces of discontinuity*, and consist of irregular joints and cracks formed in the process of solidification, or by partial disturbance previous to the general action of the elevatory force, the effects of which are to be investigated. In such cases the lines of elevation (the phænomena with which we are here principally concerned), instead of being straight or regularly curved, will be broken or zigzag lines or curves; but their general directions will be approximately the same as if the mass were uniform. Such will also be the case if the mass be *regularly* jointed in several directions. If it be jointed in two directions only, the mean line of fracture will be made to deviate more or less from the direction it would take if the mass were homogeneous, towards that of the system of joints with which the fracture makes the least angle, but still always tending to resume the direction it would have in the homogeneous mass, whenever the continuity of the joints is interrupted.

With respect to the elevatory force, it is assumed that it acted *simultaneously* throughout the disturbed area, with an *intensity* which might approximate to uniformity for large portions of that area, while it might be greater at particular points of it.

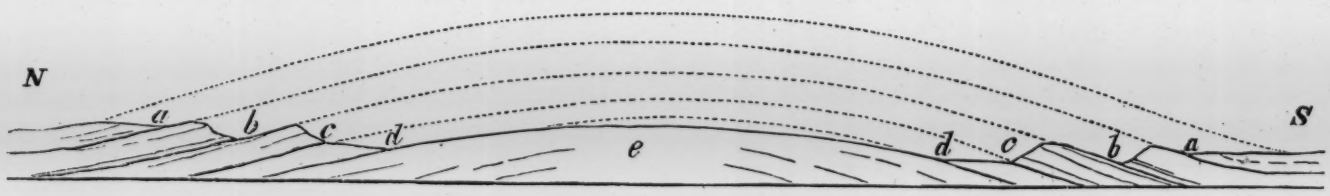
2. I have called the force *elevatory*, because the general character of most disturbed districts seems to indicate that the subterranean force, tending to elevate the earth's crust, has predominated over its weight tending to depress it; but if we suppose the contrary to have been the case, and the effect to have been a depression of the mass acted on, the phænomena with which we are principally concerned, the lines of dislocation, will follow the same law as if the mass had been elevated. It is only necessary that the resultant force at each point should generally be nearly vertical, *i. e.* nearly perpendicular to the upper and lower surfaces of the mass in its undisturbed position. I shall always speak of it, however, as *elevatory*.

3. We are not directly concerned in this theory with the physical cause to which the existence of an elevatory force may be due. Our object is to account for the varied phænomena of elevation, by referring them to some simple and general mechanical action; and, in so doing, to consider how far we may be able to define the nature of that action; whether it may have been general or local; and whether the resulting effects may be attributable to many repeated efforts, or to few. To give the greater definiteness, however, to our conception of the mechanical

action here assumed, we may observe that it is exactly that which would be produced on a nearly horizontal surface by the pressure of a fluid, the action of which, being perpendicular to the surface, would be nearly vertical.

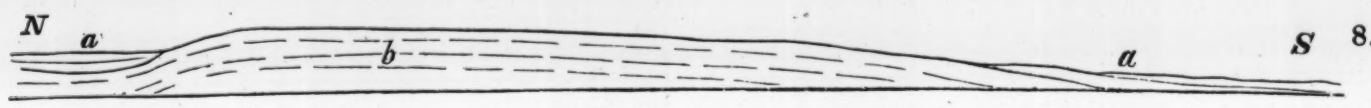
4. In applying this theory to any proposed district, we have first to consider whether the elevatory force (which, according to our fundamental hypothesis, has acted simultaneously at every point of the lower surface of the uplifted mass,) has acted with the same or with a different intensity on different portions of that surface. If the force acted under any continuous portion of the mass with a greater intensity than under another such portion, the former would, *cæteris paribus*, be more elevated and disturbed than the latter; and assuming the undisturbed positions of the component strata and the external surface to have been originally horizontal, the position of any stratum, or that of the surface immediately posterior to its elevation, and anterior to any subsequent subsidence, would indicate these two portions of the elevated mass. In determining them by observation, we must necessarily assume the external configuration of the proposed district, (independently of subsequent denudation), and the disturbed forms of the strata, to retain in a certain degree the characters impressed on them by that decisive movement to which our theory may refer the more characteristic phænomena of elevation. As an elucidation, let us take the tract of country with which we are here concerned, including the Bas Boulonnais and nearly the whole of that portion of England lying south of the Thames, and extending to the west of the Wiltshire Downs; and let us assume, for the moment, that every part of this tract was elevated simultaneously; and for the greater simplicity of the elucidation, we may also suppose it to have received its whole elevation at a single movement. To judge of the relative elevations of different portions of it immediately after this movement, we must consider what would be the form of the external surface at the present time if no denudation had taken place. For this purpose we must conceive the tertiary beds to extend over the whole of this tract (since the elevation took place posterior to their deposition), as represented in the accompanying diagrams. The

7.

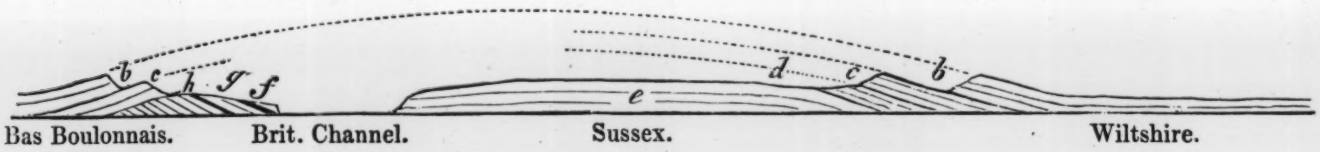


first (No. 7) represents a general section across the Weald, from north to south; the second (No. 8) a similar section west of the Wealden denudation; and the

third (No. 9) a longitudinal section along the axis of the whole district from the Bas Boulonnais to the west of the Wiltshire Downs*.



8.



9.

It thus appears that if there had been no denudation, we should have had an elevated range, the base of which would have occupied the whole of the tract defined above. The height of different portions of this range would have been very different. Within the boundary of the Wealden denudation, the greatest elevation above the sea would have been equal to the actual height of the central portion of the district together with the thickness of all the beds superior to the Hastings sand up to the tertiaries inclusive. This would probably have amounted to not less than 4000 feet, while the elevation of the western part of the range would perhaps not have exceeded 2000 feet, being its present height together with the thickness of the tertiaries.

For the purpose of presenting more distinctly to the mind the actual amount of elevation in this tract, I have supposed the tertiaries and the inferior formations now wanting to have been once continuous over the whole surface of the district. It would manifestly, however, answer our purpose equally well, if, instead of comparing the elevation of this imaginary surface of the tertiaries with their actual surface in the surrounding country, we should take the surface of any continuous stratum, and compare its elevation within the disturbed district with its depression beneath the actual surface of the surrounding district. The relative elevation of each stratum, real or imaginary, taken with reference to its undisturbed position beyond the bounds of the disturbed district, will be the same, and may be termed the *geological elevation* of the district, in contradistinction to the actual elevation of its existing surface.

Taking, then, the whole disturbed tract as above defined, since the geological elevation of the Wealden portion of it, with the Bas Boulonnais, is so much greater than that of the remaining portion generally, it is concluded, in the application of

* The following are the references to these diagrams:

a. Tertiaries.
b. Chalk, Upper greensand and Gault.
c. Lower greensand.
d. Weald clay.
e. Hastings sand.
f. Kimmeridge clay.
g. Coral rag.
h. Oxford clay.

In the Bas Boulonnais the chalk and greensand repose unconformably on the Kimmeridge clay and lower beds.

our theory, that the elevatory force acted with greater general intensity in the former than in the latter part of the district. It is also concluded, that the intensity of the elevatory force, throughout the district of greater geological elevation, so far at least approximated to uniformity, that its variation was generally much less rapid in passing from one point to another within the boundary of this portion of the whole tract, than in passing from a point within to another without that boundary.

The hypothesis of a single elevatory movement introduced, as above stated, for the greater distinctness of elucidation, is not essential to this reasoning. If we suppose the whole elevation to have been produced by successive movements, we must then apply the conclusion of the preceding paragraph more especially to that particular decisive effort of the elevatory force to which we refer the characteristic phænomena of the district.

5. The next point in the application of this theory is the determination of the boundary of the district which may have been simultaneously disturbed. This must be effected by ascertaining the area throughout which the phænomena of elevation are distinctly characterized by the same laws. Thus in the case with which we are immediately concerned, we observe that, in the western portion of the Wealden district, the longitudinal lines of elevation run approximately east and west; and such is also known to be the case in the Vale of Pewsey, and again in the Vale of Wardour. The great dislocation likewise of the Isle of Wight and the Isle of Purbeck preserves a parallel direction; and, although the evidence may not be so determinate as in the Weald, Mr. Martin has lately shown that intermediate lines, some of which may be regarded as continuations of those from the Weald into the great Wiltshire plateau of chalk, approximate to the same general law of parallelism. Hence I conclude that the boundary of the tract subjected to the simultaneous action of the elevatory forces is exterior to, and not remote from, the chalk escarpment of the Bas Boulonnais; and, after passing across the Channel from the north of Wisant to the east of Folkstone, that it is continued in like manner exterior to the chalk escarpment of Kent and Surrey, till it comes to the north of the Hog's Back and Farnham, whence I conceive it to be continued westward parallel to the general direction of the valley of the Thames, and probably not far from it (as shown by the discontinuous line in the map), as far at least as the Vale of Pewsey. On the south I consider this tract to be bounded by a line south of the southern coast of this country (see map), the exact position of which we have not the means of ascertaining; and on the west there is also some indeterminateness, arising partly from the absence of more detailed observations, and partly from the interference of other systems of dislocation which may have originated in independent elevatory movements in the south-western portion of this country. If all the strata removed by denudation were replaced, the above

boundary, with the exception of the western extremity, would be distinctly indicated by the resulting mountain range.

6. To define the boundary of that portion of the district which is conceived to have been subjected to a more intense action of the elevatory force than the other portions, we must suppose the boundary line to turn southward at Farnham, and to preserve the same relation to the chalk escarpment from thence by Petersfield to Beachy Head, as that above described with reference to the other portions of that escarpment, and to pass across the Channel from that point to the southern boundary of the Bas Boulonnais. The boundary of the portion of the district now referred to is indicated in the map by a discontinuous line, which will be easily recognised.

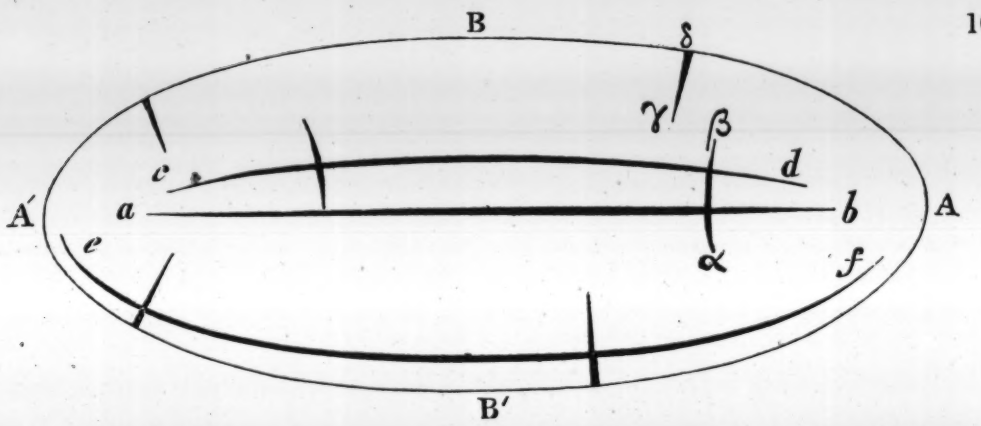
Having established these preliminary points respecting the action of the elevatory force and the boundaries of the disturbed district, we must determine the general directions of lines of dislocation which would be formed in the elevated mass, assuming its approximate homogeneity. If it be not homogeneous, the lines of fracture may be modified as previously explained (page 31), but the results will still be approximately true.

7. It has been shown in the memoir already referred to, in the Transactions of the Cambridge Philosophical Society, that if the elevatory force be uniform, and the boundary of the elevated area be circular, a system of fissures might be formed, concentric about the centre, or diverging as radii from it. If the force acted with much greater intensity at the centre than elsewhere, the latter system would generally be formed, and not the former. It would then become a case of what I have termed *conical elevation*. If the circle be of large extent, and the force approximately uniform and of sufficient intensity, both these systems might be formed in a mass constituted like that we have to consider. If, on the contrary, the elevated area were a parallelogram of finite breadth, but of indefinite length, one system of fissures only could be formed. Its direction would be parallel to the axis of the parallelogram.

Now the circle, and the parallelogram of indefinite length, may be regarded as the two extreme or limiting cases of the ellipse, or, more generally, of any regular *oval*. For conceive an oval always preserving its shorter axis the same in magnitude and position, to change its form by a change in the magnitude of its greater axis. When this variable axis is equal to the constant one, the oval will become circular; and when the variable axis becomes indefinitely great, the oval will approximate more and more nearly to two straight lines parallel to the greater axis and passing through the extremities of the minor one. And as the general form of the oval is intermediate to these two extreme or limiting cases, it is not difficult to see, that the curve along which a longitudinal fissure would be formed under

our assumed conditions, when the boundary of the elevated mass is oval, will be generally intermediate to the straight line and circle, in the sense in which the oval is so. In the particular case in which the fissure should be *central*, it would be a straight line along the axis; if *lateral*, it would deviate more from the straight line and approximate more to the form of the external oval boundary, according as the position of the fissure should be more remote from the axis, as represented in the following diagram (No. 10). The conditions of symmetry are sufficient to

10.

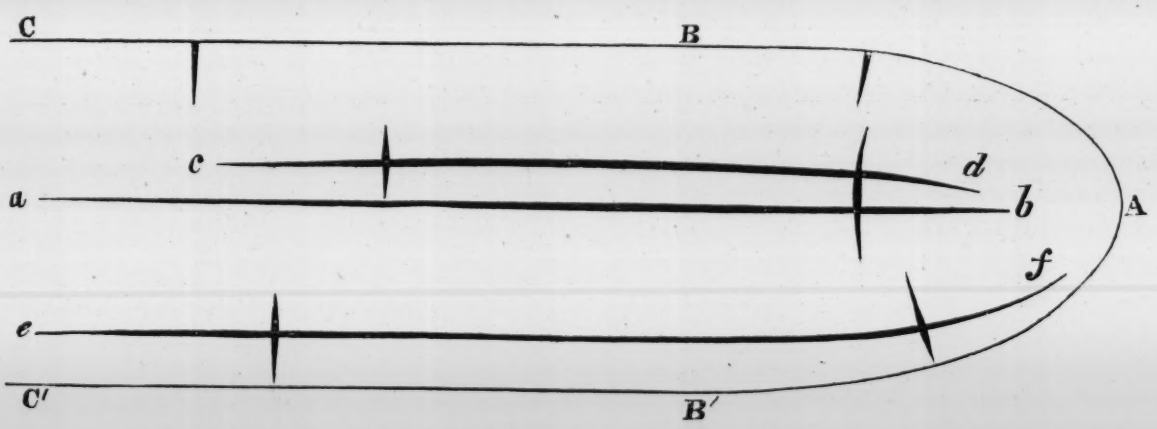


establish these results, without entering into the mechanical reasoning on which they really depend.

A system of transverse fissures ($\alpha\ \beta$, $\gamma\ \delta$, &c.) might also be formed, the law of which, as theoretically determined, would be, that every such fissure should be perpendicular to each longitudinal fissure at the point of intersection.

Let us now take the case represented in No. 11, in which the extremity, A, of the disturbed district has the same form as in the previous case, while the portions B C and B′C′ of the boundary are continued indefinitely and parallel to each other.

11.

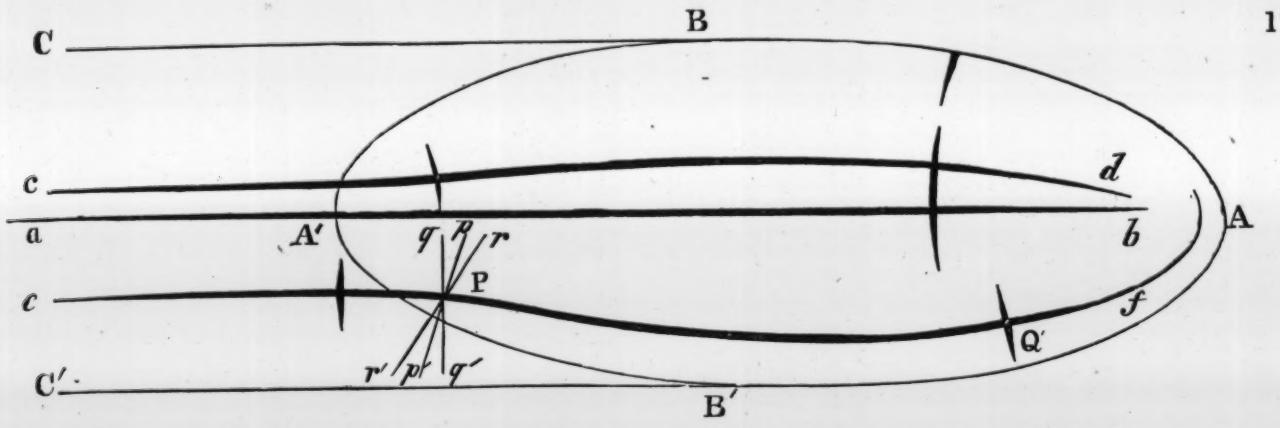


Towards A, the longitudinal lines of fissure will evidently be curved, as in fig. 4; but between B C and B′ C′, they will be parallel to those lines. The transverse fissures, if formed, will always follow the same general law with reference to the longitudinal fissures as in the previous case.

Again, let us take the case formed by a combination of the two preceding cases,

the portion A B A′ B′ (No. 12) being supposed to be acted on by an elevatory force

12.

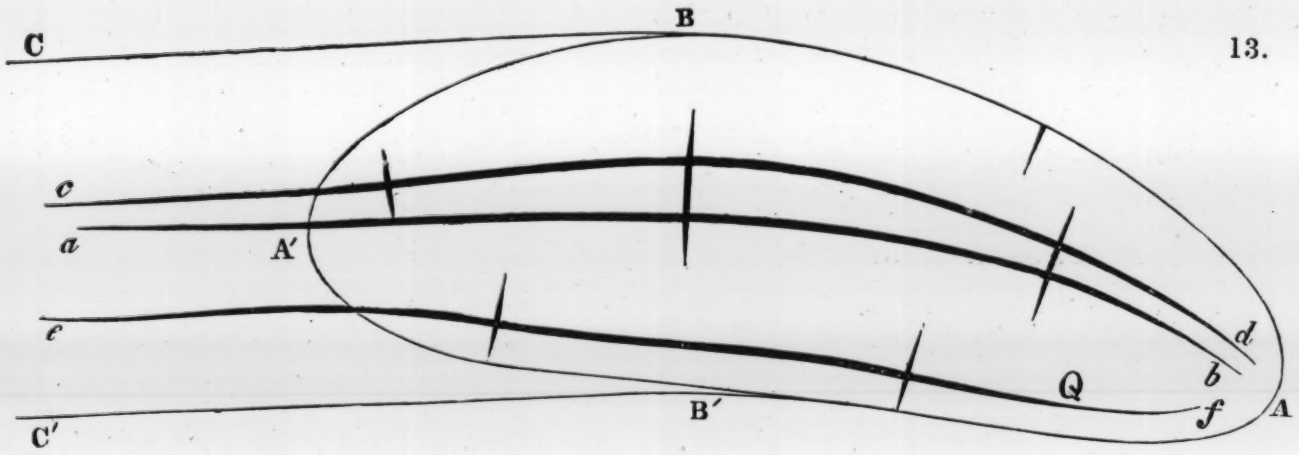


of greater intensity than the remaining portion. Let F denote the force acting on this latter portion, and let that on the former be equal to the sum of F and an additional force (f). If F alone acted on the whole area, we should have the case of fig. 11; and the question is, how would the fissures of that case be modified by the contemporaneous action of f, in addition to F, on the oval A B A′ B′? Now if f acted alone on that portion, and F did not act at all, either in that or the other part of the district, we should have the case of fig. 10, and therefore it is obvious that the modification produced by it would be such as to make the lines of fig. 11 approximate more or less to those of fig. 10, in the manner represented in fig. 12, the direction of a fissure through any point situated like P being intermediate to those in which it would proceed through that point in the two preceding cases respectively.

This conclusion follows immediately also from the consideration that the direction of the longitudinal fissures at any point will be perpendicular to the direction of greatest tension at that point*. Thus, if the force acted uniformly throughout the whole space A C C′, the direction of greatest tension at the point P would be $q\,q'$ perpendicular to the axis A A′; and if the force acted on the oval alone, the direction of greatest tension would be in some such direction as $r\,r'$. Consequently, in the actual case proposed, it is obvious that the greatest tension will have a direction $p\,p'$, intermediate to the two former directions, and therefore also, the direction of the fissure will be intermediate to those which would be formed in the previous cases respectively.

* This may admit of exceptions, but will be true whenever there is a greater tendency to form longitudinal than transverse fissures. At certain points, not remote from the extremities of an elongated oval, the tension along $r\,r'$ may be a minimum; in which case the direction of maximum tension will be perpendicular to $r\,r'$, and the transverse would probably be formed first; but in such case the longitudinal one, if formed at all, must be perpendicular to the transverse one, and the conclusion of the text would still hold true.

We may now pass to the case represented in fig. 13, which differs from fig. 12



13.

in having for the axis of the oval a curved instead of a straight line. To estimate the effect produced by this change of form on the direction of the longitudinal fissures, conceive the area A B A′ B′ uplifted and thus placed in that state of tension which it can just support without dislocation. If we take a point Q in the portion B A B′ of the oval, it is not difficult to see that the line of greatest tension through Q must (to a degree of approximation sufficient for our present purpose) bear the same relation to the curved axis of the oval, as the corresponding line through Q′ in fig. 12 bears to the rectilinear axis in that case. Consequently the directions of longitudinal fissures through Q and Q′ (which must be perpendicular to the lines of greatest tension) must also bear similar relations to the two axes respectively. Consequently the line of fissure through Q, instead of curving upwards as in fig. 12, may curve downwards, as represented in fig. 13, provided the curvature of the axis be sufficiently great. The curvature of the lines of dislocation on the side of the axis opposite to Q will evidently be increased by that of the axis. A fissure near the axis will obviously be approximately parallel to it.

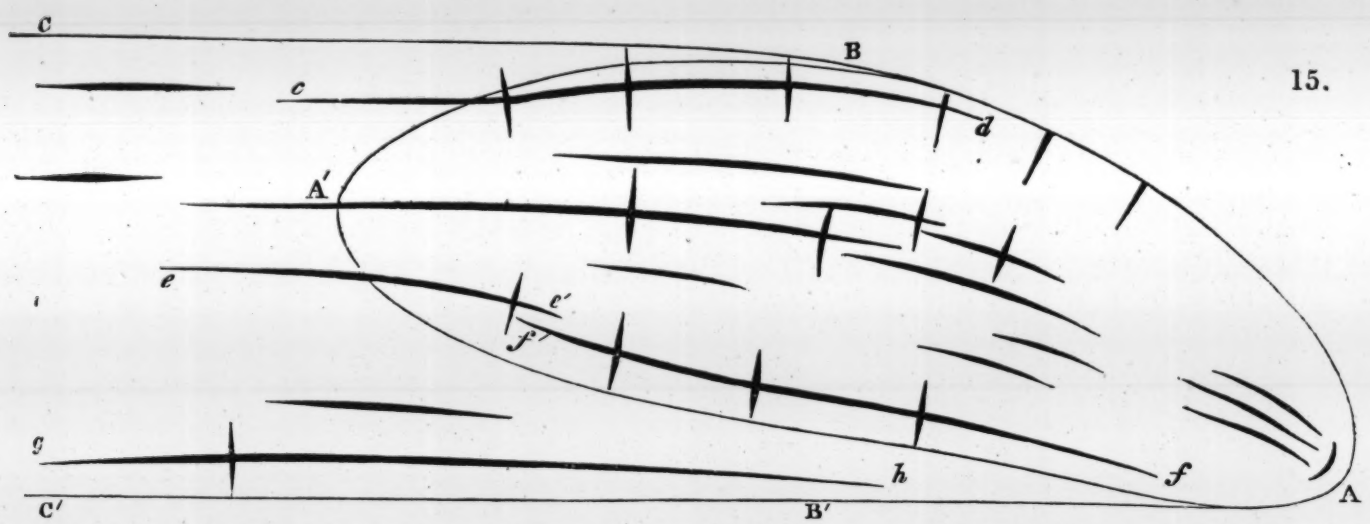
In the preceding diagrams, I have represented, for the sake of simplicity, only one central and two lateral longitudinal fissures; but I have shown in the memoir so often referred to, that under very probable conditions, instead of a single continuous fissure, we should have several parallel fissures; so that if, for instance, we take the simple case of a uniform mass, of which the surface is a parallelogram of indefinite length, elevated by a uniform force, we should have a system of fissures such as represented in the annexed diagram (14). It should be observed,



14.

that we cannot possibly know sufficiently the exact conditions of the problem to determine the precise position of each individual fissure; but we know that every longitudinal fissure must, in this case, be parallel to the sides of the parallelogram, and that thus the whole system must possess the distinctive character of parallelism.

In like manner we may replace the longitudinal fissures of fig. 13 by any other system in which the direction of each fissure, or rather the curve line in which it meets the surface, shall be in accordance with the law distinctly indicated by that diagram. Thus we may take the system represented in fig. 15, where, instead of a single central longitudinal fissure, we have several, and where the lateral fissure *e f*



15.

(fig. 13) is replaced by two, *e e′* and *f′ f*. The law of this system is no longer that of strict parallelism, nor can it be simply described. It is one, however, which is obvious to the eye, and must characterize the whole system formed under the conditions contemplated in this case, whatever may be the position of the individual fissures with respect to their distances from the sides or extremities of the district. Of the different systems which might be thus formed and characterized by this law, I have selected one in fig. 15 bearing a close resemblance with the actual district under consideration, to facilitate the comparison between this theoretical diagram and the observed phænomena. The boundary A B′ C′ has also been varied from fig. 13 for the same purpose. The system of transverse fissures is represented by the transverse lines.

8. To bring the results of our theoretical investigation to an actual comparison with those of observation, I have further to remark, that, according to our theory, all the *secondary* phænomena of elevation, such as faults, anticlinal lines, lines of curvature, &c., are the immediate consequences of the *primary* phænomena of fissures, and must, therefore, follow corresponding laws. Hence the lines, representing fissures in fig. 15, may represent the corresponding lines of elevation, such as constitute the objects of direct observation. To test the accuracy of our theory,

then, as applied to the Wealden district, we have only to compare our theoretical diagram (15) with the map on which the observed lines of elevation are delineated.

In doing this, we may, in the first place, direct attention to the central system of observed longitudinal lines. We have not one line, but many, all of which have the same curvature as the geometrical axis of the district; and we may remark that the three lines of the Bas Boulonnais have exactly the directions they ought to have, if considered as the prolongation of the central system across the Channel. All this is in accurate accordance with our theoretical diagram. Nor is the Greenhurst line less curiously accordant with the line *e f* (fig. 15)*. The line by Seven Oaks and Farnham agrees with the theoretical line *c d* and the line *g h* also becomes almost the exact representative of the well-known line of the Isle of Purbeck and the Isle of Wight. The central transverse system of fractures follows the theoretical law, as do the fractures also of the chalk escarpment, assuming its transverse river-courses to have originated in such fractures, and the directions of dislocation to coincide with the direction in which the actual rivers penetrate the chalk. It will be observed that the courses of the Wey and the Mole through the northern escarpment are very nearly north and south, while those of the Darent, the Medway and the Stour incline successively more to the north-east as the general axis of the district, and the central longitudinal lines incline to the south-east. This is exactly in accordance with our theoretical deductions; and though we have no right to cite this harmony as one of the proofs of the theory, in the same manner as if the origin of each river-course in a dislocation had been established by more positive evidence, we may insist upon it as affording strong corroboration of this view of their origin, and of the theory by which we are accounting for it.

The only sensible deviations from the directions which our calculations assign to the lines of elevation are found in a few of the transverse fractures, more especially in the Seven Oaks ridge, which appear to bear somewhat more to the north-east than the corresponding lines in the theoretical diagram (15). These latter lines, it will be recollected, are determined on the supposition that the structure of the elevated mass has been such as to exercise no sensible influence on the directions of the lines of elevation. It is not, however, contended that the hypothesis is necessarily true. The extent to which it must be received in any particular district, is to be determined by the degree of accordance between the observed and calculated results. The almost perfect accordance in the case before us affords the most conclusive proof that can be offered, of the general truth of the supposi-

* It is easily seen from our observations, at the close of the last article, that this accordance may be regarded as equally perfect, whether the Greenhurst line be one continuous line towards Petersfield, or be formed of two lines, as represented in the map. (See Greenhurst line, p. 15.)

tion in this particular instance; but in those localities where we observe a want of this perfect accordance, we must necessarily recognise the operation of some modifying cause. The transverse fissures just mentioned present an instance of the kind; and the modifying cause was probably the jointed structure of the mass in the locality in which they exist; for it appeared to me that the predominant joints in the neighbourhood were such as would be likely to produce exactly the kind of modification recognised in the directions of the transverse dislocations.

And here we may remark, that the great tendency of an approximately uniform elevatory force, in a tract of which the length is much greater than the breadth, would be to produce *longitudinal* fissures, since the directions of greatest tension would manifestly be perpendicular to the longer axis of the district, except at its extremities. The formation of *transverse* fissures might, in such cases, be due, in a considerable degree, to local irregularities in the action of the elevatory force, or in the constitution of the mass. The longitudinal fissures would be formed *first*, and their prior existence would, in a great measure, determine the directions of the transverse fissures, whether the latter were formed at the next instant during the same elevatory movement, or at any subsequent movement. This cause, however, as respects its influence in fixing the directions of the transverse fissures, would frequently be less determinate than the general action of the elevatory force, in fixing those of the longitudinal fissures; and, therefore, while the latter might remain sensibly unaffected, the former might be materially modified by the irregularities above mentioned in the action of the force, or in the constitution of the mass. Such modifying causes must necessarily exist in all cases; but we can have no means of calculating their effects. In some instances they might be sufficient to destroy all symmetry and apparent law in the resulting phænomena; but in the instance before us, the accordance between observed and calculated results assures us that the influence of merely local causes has been extremely small.

In this harmony between facts and theory we observe something more than a *first approximation* to accuracy. If nothing more had been established by observation than that there were certain lines of elevation of which the general directions approximated to east and west, and others which were directed nearly to the north and south, and a theory had been offered assigning some probable cause for *this law of parallelism*, such theory might have been deserving of attention as a first and rough approximation to a more accurate one. But the theory which I have been applying to the Wealden district does not stop at this point. It not only assigns a physical cause for the general law of parallelism, but, wherever the data of the problem are sufficiently determinate, it shows the manner in which the lines of elevation will deviate from this parallelism in each particular district. In the case before us, the deviations of the longitudinal lines from rectilinearity and from

accurate parallelism with each other, according to theory, have been distinctly pointed out, as well as the manner in which the transverse lines are related to the longitudinal ones, and their consequent deviation also from accurate parallelism. The exact accordance of these deviations with those which I have established by observation in the Wealden district constitutes the most complete proof which a theory of elevation can admit of in its application to any district in which we can observe little more than the lines of elevation, and have no means of examining those more minute details of geological structure which the operations of the miner alone can lay open to us.

9. One conclusion from this theory is, that the whole tract previously defined as extending from the Bas Boulonnais to the south-western part of England was raised by a force acting contemporaneously at every point of the lower surface of the elevated mass, for that hypothesis has been proved *sufficient* to account for the observed phænomena. Moreover, it is *necessary*; for if this were not the case, conceive this area divided into separate portions, each of which was elevated separately. Then, since it has been shown that the form of the area simultaneously elevated is one of the most essential circumstances on which the directions of dislocation depend, it is manifest that those directions would follow different laws in the different portions successively elevated, which is contrary to the observed phænomena.

10. There is another point of interest on which our theory does not enable us to arrive at an equally demonstrative conclusion: I allude to the question respecting the manner in which the district may have attained its actual geological elevation; whether by one great upheaval, or by many successive minor ones. The only demonstrative inference to which our theory leads us is this,—that there must have been one considerable decisive and simultaneous movement by which the dislocations of the elevated mass were produced; and I should further regard it as highly probable that this movement was sufficient to impress upon the district its most distinctive and characteristic features, as far as they depend on its geological elevation. I shall not here, however, enter into a discussion of the mere probabilities of the question, for which, in fact, a theory of the denudation of the district is scarcely less essential than that of its elevation. I will only observe, that while we are compelled, as I conceive, to recognise the decisive movement above described, considerations connected with the denudation of the district equally constrain us to recognise in it the slow process of continental elevation.

11. Our theory also leads us to the inference, that extensive cavities formerly existed within the solid portion of the earth's crust, and, if not always, were at least sometimes filled with fluid or gaseous matter, to the expansion of which the elevation and fracture of the superincumbent solid crust is to be attributed. Eleva-

tion and fracture might undoubtedly be produced by the expansion of a *solid* mass immediately beneath the superficial crust, but the phænomena of *faults*, in which the beds on one side of a dislocation are frequently raised to so considerable a height above the corresponding beds on the other, would manifestly not result from this kind of expansion; and therefore it is concluded that the elevation must have been owing to the expansion of a *fluid* or *gaseous* mass, since there appears to be no other conceivable mode of producing the elevatory force. I shall now endeavour to explain how we may distinctly conceive the requisite mechanical action to have resulted from this agency.

It will be recollected, that in the investigations by which the effects of elevatory forces have been determined, the elevated mass has been assumed to be *fixed* at each point of its boundary,—a condition which is manifestly satisfied by the hypothesis of an internal cavity, co-extensive with the surface of the elevated district. If the observed phænomena be such as are referable to an approximately uniform action of the elevatory force, they will only require the hypothesis of a continuous and uninterrupted cavity, occupied by matter possessing the property of fluidity in a very considerable, though not necessarily in a perfect degree. In general, however, the phænomena indicate a more energetic action in particular portions of the disturbed district, and in such cases some additional considerations become necessary. For the greater simplicity, I have usually considered these phænomena as due to a more intense action of the elevatory force, the resistance of the uplifted mass being uniform. This resistance, however, may be different in different portions of the mass, and the resulting effect will then depend not merely on the intensity of the elevatory force, but on the ratio which that intensity bears to the resistance opposed to it; so that the effects will be the same, whether the force be variable and the resistance uniform, or the converse. Thus, for instance, the greater geological elevation of the Wealden district as compared with that of the other portion generally of the whole disturbed tract, might be referred to a smaller resistance of the uplifted mass; to account for which, we have only to suppose a certain portion of the superior beds which are now wanting in that district, not to have existed there at the epoch of its elevation. The absence of this superincumbent weight, conjoined with a uniform force throughout the whole disturbed tract, would manifestly be equivalent to the action of a greater force beneath that portion of the district, conjoined with a uniform mass; and the phænomena of elevation would in either case be sensibly the same.

If we would refer a greater relative geological elevation to a greater intensity of the elevatory force, it may be desirable (though not essential to our immediate object, as stated in Art. 3.) to explain how that intensity might be greater in one part of the internal cavity than in another, notwithstanding the tendency of a

fluid to exert an equal pressure in all directions. For this purpose we may first suppose the fluidity of the matter contained in the cavity to have been *imperfect*, like that, for example, of newly ejected lava; or, secondly, we may suppose the communication between one continuous portion of the cavity and the contiguous portions not to have been perfectly free, but partially impeded by solid masses, capable of resisting fusion at the temperature of the surrounding matter. The whole general cavity might thus consist of several portions, with obstructed communications, like a number of lakes connected by comparatively narrow or shallow channels. Under such conditions, if any cause of expansion were to act with greater intensity on the fluid contained within one of these internal lakes, the fluid pressure throughout it might be approximately uniform, and much greater than that transmitted by the imperfect fluid through impeded channels to the surrounding lakes. We should thus obtain that kind of action of the elevatory force which, as above shown, the phænomena of the Weald require for their explanation*.

12. Other suppositions respecting the structure of internal cavities might also enable us to account for the existence of a fluid pressure, acting with different intensities on different portions of the elevated mass. It is not, however, my object at present to enter further into speculations of this nature; nor is it here necessary for us to consider to which of these hypotheses the greatest probability of truth may attach, or whether the greater observed elevation of such a district as the Weald may have been due to the more intense action of the elevatory force, or the greater weakness of that portion of the elevated crust. It is enough to have shown that the hypothesis of internal cavities does enable us to assign a distinct and simple cause for the mechanical action necessary to account for such phænomena of elevation as we find in the Weald and in other analogous districts.

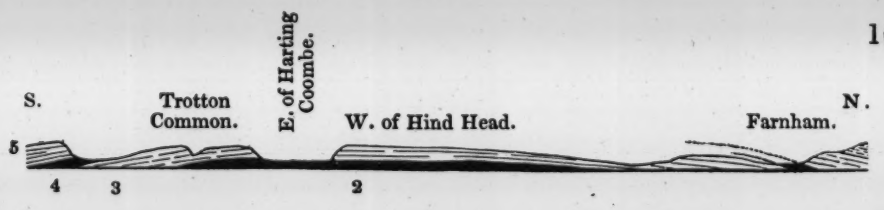
I shall not, by here touching upon other points of our theory, lengthen a communication which has already exceeded the limits I had intended to prescribe to it. This has arisen from an anxiety to avail myself of the occasion afforded by the admirable example before us, to elucidate the fundamental points and some of the more important results of the theory in its application to the Weald and all similar districts. I have thus hoped also to correct some imperfect, if not erroneous conceptions which have been entertained on this subject, whether they may have arisen from an imperfect development of my own views, on my part, or an imperfect comprehension of the conventional meaning of the language I have used, on the part of the reader. Such conventional language must necessarily appertain to every branch of science, nor can it be perfectly understood without a clear knowledge of, at least, the fundamental principles and simpler applications of the science to which

* It appears to me that the existence of internal lakes *with obstructed communications* affords the best explanation of the phænomena connected with earthquakes and volcanic action in South America.

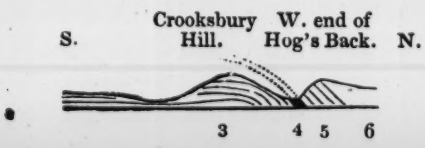
it belongs. Thus it may happen that expressions which are strictly calculated to convey perfectly accurate notions of the reasoning employed or the results arrived at, may, when addressed to persons imperfectly acquainted with the language of the subject, convey conceptions either positively erroneous, or at least devoid of that distinctness and precision without which they become comparatively valueless. Such, perhaps, is especially the case in the application of mechanical science to the problems which geology presents to us. In these problems, approximate solutions only can be sought for; and the sense in which the language of mechanics, as an accurate science, is constantly used, can only be completely understood by those who can understand, from the nature of the problem proposed, the degree of approximation which may be attainable in its solution. In some instances it must be impossible to obviate this difficulty on the part of the reader; in others it could only be done by a verbal prolixity, which might justly be deemed intolerable in a communication to a scientific body. Under the impression however, that many geologists who have not devoted their attention to mechanical science might feel an interest in these theoretical views on geological elevation, I have ventured, in this memoir, to give such repetitions of former statements and such detailed explanations as may tend to render the subject more generally intelligible. Should this object be accomplished, it will be deemed, I trust, a sufficient apology for the want of that greater brevity which it is generally desirable to maintain in original communications on scientific subjects.

TRANSVERSE SECTIONS ACROSS THE WEALDEN DISTRICT.

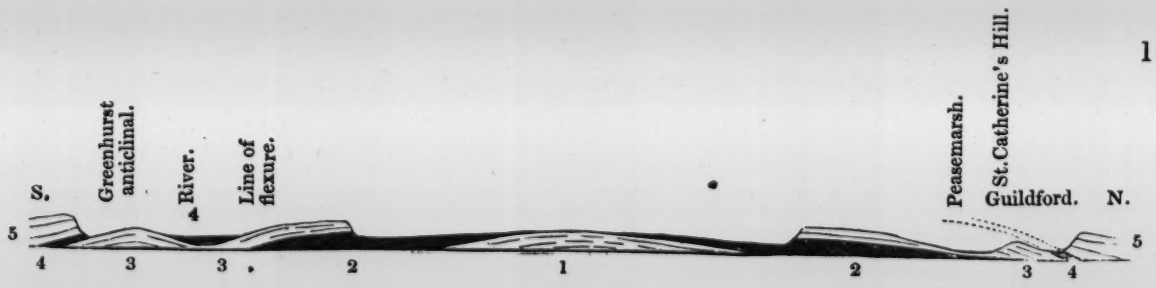
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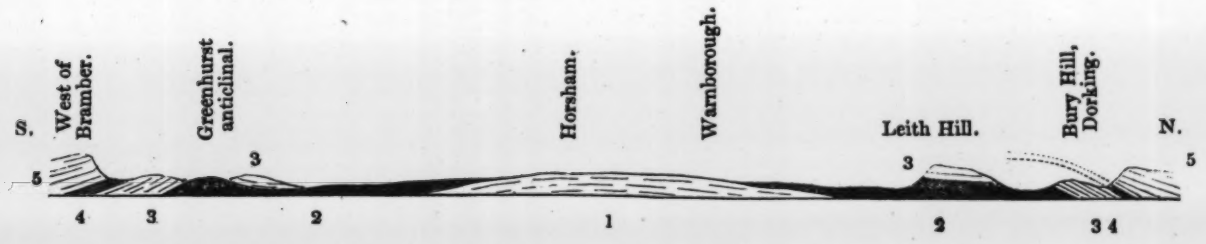
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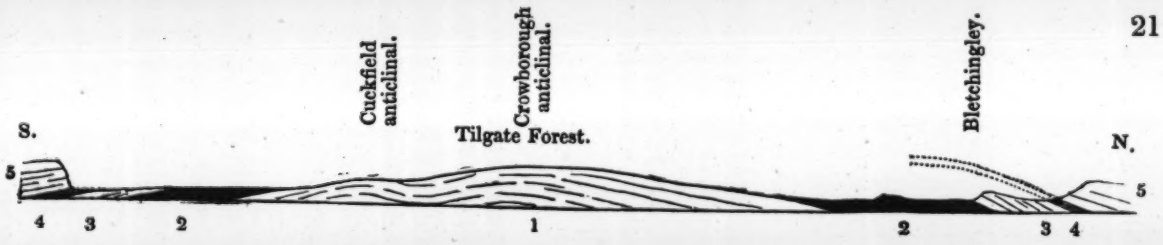
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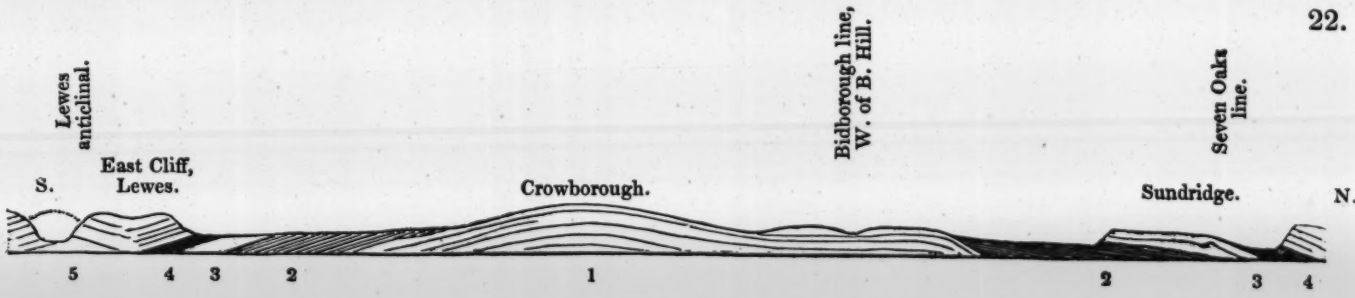
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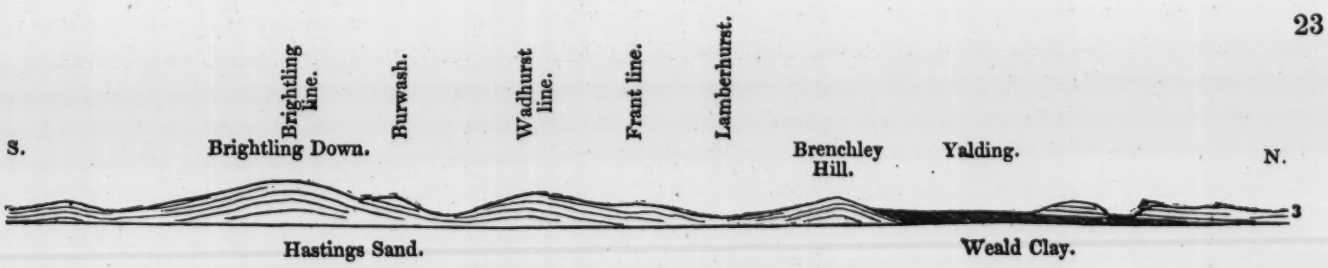
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23.



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25.



References.

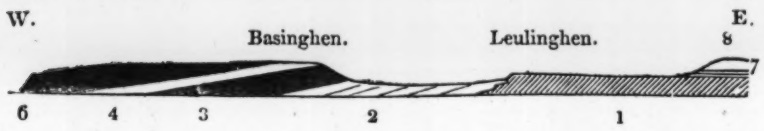
6. Tertiary strata.
5. Chalk and Upper Greensand.
4. Gault.
3. Lower Greensand.
2. Weald Clay.
1. Hastings Sand.

Description of the preceding Sections.

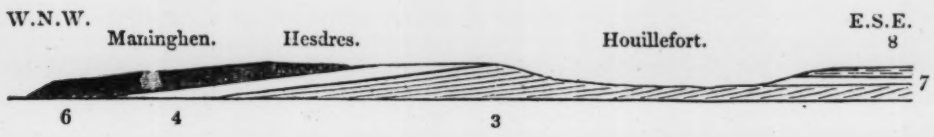
Of these sections the first (16) exhibits, near its southern extremity, the line of flexure which Mr. Martin is disposed to consider as the continuation of the Greenhurst anticlinal line. At its northern extremity it is intended, in conjunction with (17), to show the great change which takes place in the dip of the chalk after we pass the western extremity of the Hog's Back, as mentioned in the description of this part of the district. Section 18, at its northern end, exhibits the Weald clay just appearing at the surface in Peasemarsh, as described by Dr. Fitton and Mr. Martin. The latter gentleman considers his Peasemarsh line as running from thence through Crooksbury Hill. The southern end of this section exhibits the Greenhurst line, with the patch of gault to the north of it, as well as the line of flexure which I have described as passing from Pulborough to Trotton Common. Section 19 shows the manner in which the rapid dip is continued to the top of Margaret's Chapel Hill, and, together with (20) and (21), shows the continuation of the great line of flexure near the chalk escarpment of the North Downs. Section 20 also exhibits the Greenhurst anticlinal at the point where it brings up the Weald clay in a valley of elevation. Section 21 exhibits the Crowborough and Cuckfield anticlinals. Section 22, at its northern end, shows the Seven Oaks line, and at its southern end the Lewes anticlinal, supposed to be a continuation of the Greenhurst line. This section and (23) also exhibit the Bidborough and Brenchley line, which is generally a line of flexure, but assumes the anticlinal arrangement at Brenchley Hill. In the latter section we also recognise the Frant, Wadhurst and Brightling lines. Section 24 exhibits the two distinct anticlinals through Battle and St. John's Cross, into which the Brightling appears to be divided to the east of Brightling. Section 25 is perpendicular to the Battle and Bexhill lines, exhibiting the fault in the low sea-cliffs near Bexhill.

In the *lengths* of these sections the scale of the Ordnance Map, one inch to the mile, has been reduced to $\frac{1}{24}$th of an inch to the mile. In the *heights* no topographical accuracy has been aimed at. The object has been to give a clear conception of the character of the phænomena of elevation which the district presents.

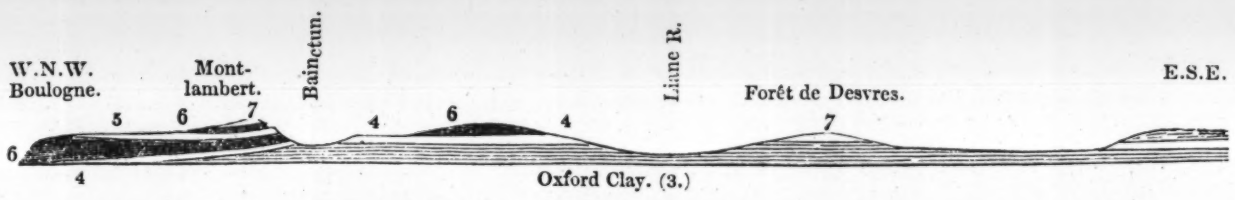
SECTIONS OF THE BAS BOULONNAIS.



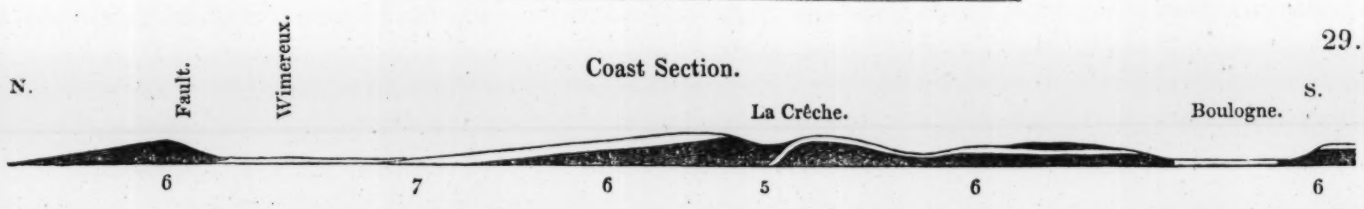
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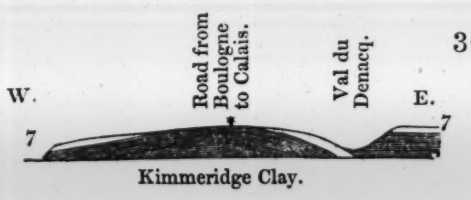
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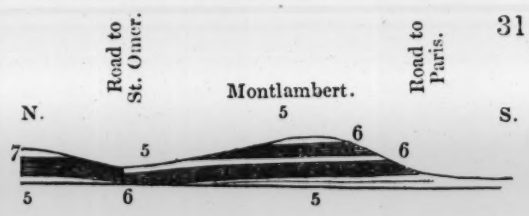
28.



29.



30.



31.

References.

8. Chalk, Upper Greensand and Gault.
7. Beds between the Gault and Kimmeridge Clay.
6. Kimmeridge Clay.
5. Sand beds in the Kimmeridge Clay.
4. Coral Rag.
3. Oxford Clay.
2. Oolite.
1. Mountain Limestone.

Description of the Sections of the Bas Boulonnais.

The preceding group represent sections of the Bas Boulonnais. The first three (26), (27), (28), are nearly parallel to each other, and nearly perpendicular to the direction of the coast north and south of Boulogne. The first shows the unconformable position of the lower oolite on the mountain limestone about Marquise and Leulinghen, and of the cretaceous system in the north-eastern corner of the district. The second section shows the superposition of that system on the Oxford clay. The third (28) exhibits the structure of Montlambert, the highest hill within the chalk boundary. The rapid rise of the beds on its east side brings up the Oxford

clay in the valley at Bainctun. At the eastern end of the section, the cretaceous system is again observed to rest immediately on that clay, as does the lower part of it also in the Forêt de Desvres. These sections are on a scale about twice as great in length as those of the Wealden district; section (29) is on a scale about eight times as great. It is a section of the coast north from Boulogne. The line of La Crêche is finely exhibited in the cliff. The section also shows the fault at Wimereux; the beds continued from La Crêche to *a* beneath the surface of the sea, would on the north side of the fault be found at *a'*, if they still existed there, as they do within less than a mile of the beach. From the fault the beds are observed to descend towards the north into the next valley; from which they rise again on the north of Auxdresselles, forming the third line represented on the map, in proceeding northward from Boulogne. Section 30 shows the fault by which the valley of the Denacq is formed, and section 31 represents that of Montlambert in a direction perpendicular to that given in (28); it also shows the continuation of the line of La Crêche near the St. Omer road, where it assumes the character of a fault. The valley of the Denacq on meeting this fault assumes its direction.

In these sections, the beds between the gault and Kimmeridge clay are not distinguished from each other. The upper portion of these beds is undoubtedly the lower greensand of our own country. The lower portion is considered to belong to the Portland formation. The former portion consists almost entirely of ferruginous sand; the latter contains huge calcareous blocks, sometimes forming irregular beds, which are worked, in many places, for building and other purposes. There are large quarries of this kind on Montlambert, where the beds are immediately above the Kimmeridge clay; and also near the column of Napoleon, immediately on the *north* side of the fault of La Crêche, by which, on the *south* side, the lower beds of the Kimmeridge clay are brought up to the level of the quarries.

Description of the Map.

Plate I.

The map contains the Bas Boulonnais on the east, and the disturbed district, mentioned in the memoir, as far west as Southampton. The greater part of the great Wiltshire plateau of chalk lies still further to the west, and is too extensive to be included.

The *boundary of the disturbed district*, denoted by a black dotted line, comprises that extent of country (as far as the map extends) which I conceive to have been *simultaneously* disturbed. The interior dotted black line indicates that part of the district in which the elevatory force is conceived to have acted generally with greater intensity than in the remaining portion. It comprises the whole district of the Weald (as defined by the great Wealden denudation) and that of the Bas Boulonnais. These boundaries are, of course, to be considered as only approximate, and independent of local irregularities.

The red lines are *lines of elevation*, whether they be faults, anticlinal lines, or lines of curvature. The continuous red lines denote lines of elevation clearly established by observation; the dotted lines denote those the existence of which rests on less positive evidence. Synclinal lines are not marked.

The map has been engraved on a reduced scale from that of the Ordnance Survey.

6711

II.—*On the Discovery of the Fossil Remains of* Bidental *and other* Reptiles *in South Africa.*

By ANDREW GEDDES BAIN, Esq.

Abridged from a letter addressed by the Author to Sir Henry De la Beche, For. Sec. G.S., and dated "Fort Beaufort, April 29, 1844."

[Read January 8th, 1845.]

PLATE II.

HAVING been employed, during the last seven years, under the Officers of the Corps of Royal Engineers, in superintending the construction of military roads in the colony of the Cape, more especially on its eastern frontier, and having also travelled far beyond that frontier in a northerly direction, I have had opportunities of observing the geological structure of that part of South Africa; and I venture therefore, although only a self-taught geologist, to submit the following observations to the Geological Society.

My principal field of research has been the tract of country extending northwards from the sea-coast of the county of Albany to the heads of the rivers which enter the sea on that coast*. The sea-boundary of this county, commencing about 450 miles to the east of Cape Town, at the mouth of the Boschman's river, runs in a north-easterly direction about seventy miles, to the mouth of the Keiskamma river. In this length of coast are the mouths of the Great Fish and Gualana rivers, the former about 500 miles east of Cape Town, the latter about fifteen miles further to the north-east. The portion of the tract of country above described which I have examined with most attention, lies between the coast and the northern foot of the Winterberg mountain, whose summit is at the distance of nearly ninety miles from the sea. Respecting the country further in the interior I have also given some geological notices.

In this eastern extremity of the colony no granite has been observed; but the lowest rocks seen near the coast belong to a stratified series. Since their dip, though variable, is, in the main, from the sea inwards toward the land, it is the lower members of the series that are found nearest the coast; and of these the fundamental rock is a red quartzose sandstone, highly crystalline in parts, and alternating with a talcose slate. Its strike is east-south-east and west-north-west, and this direction is very constant; but the dip is extremely variable. An instance of this occurs near Graham's Town, the capital of the eastern province, where,

* See the Maps, Plate II. and in page 55.

within a distance of 280 yards, measured at right angles to the strike, I counted six anticlinal axes; and found the strata at the summit of each axis bent at an acute angle, like a ridge-tile, and the rock highly crystalline.

The only data I have obtained, which may serve to indicate the age of this sandstone, are derived from a few vegetable casts and impressions, first discovered by Dr. G. Atherstone, and which appear to belong to a Lepidodendron. The best specimen of these markings in my possession is too bulky for transmission to England.

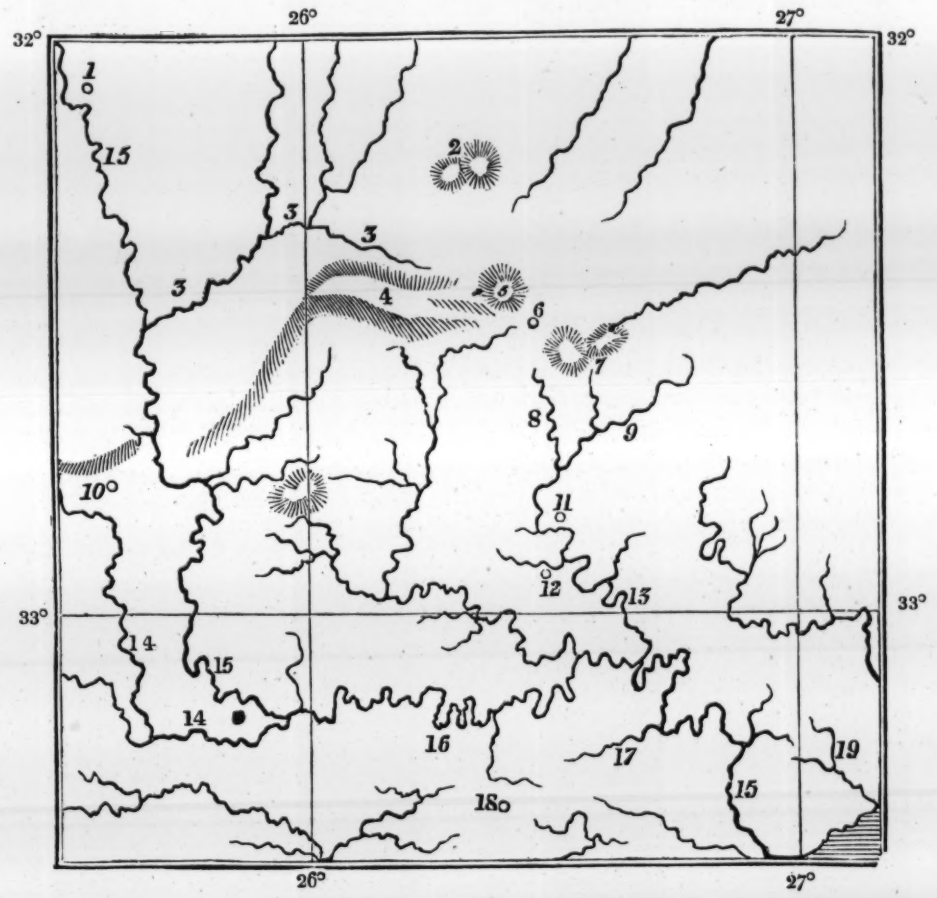
This rock is found on the coast at the mouth of the Great Fish river. Its northern boundary passes eight miles to the north of Graham's Town, that is, about thirty-five miles from the coast. To this formation belongs the rugged mountain chain, the Zwarte Berg, which runs about seventy miles inland, in a line parallel to the southern coast of the colony. I have also traced it further westward to the mountains on the Hex river, near Worcester, about sixty miles north-east of Cape Town. There it turns to the north-north-west, in the direction of the country of the Namaquas.

The next rock, in ascending order, is a claystone porphyry, consisting of a clear blue base, with numerous imbedded pebbles of quartzite, claystone, &c. It occupies the troughs in the undulating sandstone just described, which are bounded by parallel mountain-ranges of the same rock. In the hollows of some of these troughs it is from 300 to 500 feet thick, and, when seen in mass, has no appearance of bedding. It thins off towards the sides of the troughs. It often appears on the surface in small tongue-shaped portions, projecting from the ground at an angle of from 70° to 80°, and looking like gravestones in a churchyard.

I have traced one of the ridges of this rock through a distance of eighty miles, from the point where the ridge emerges from the sea, at the mouth of the Gualana river, to the point where the Great Fish and Little Fish rivers unite. The formation extends, I believe, much further both to the east and west. Its northern boundary, like that of the quartzose sandstone, passes eight miles to the north of Graham's Town.

I shall now take my course from Graham's Town, along the military road called the Queen's road, which runs northward to Fort Beaufort, forty-six miles. At the eighth mile the clay porphyry is overlaid conformably by a formation of great thickness, consisting of an argillaceous slate alternating with sandstone, and containing thin laminæ of hard, blue, impure limestone. Further northward, at the Ecca heights, this slate contains a stratum nine inches thick, consisting entirely of vegetable remains. At the Great Fish river the dip of the slate, which at the eighth mile was 30°, is reduced to 5°. The same formation continues northward about four miles further along the left bank of the river. Then a valley of elevation occurs, as if to allow the river a passage, and the slate is replaced by a green-

ish sandstone containing a number of blue calcareous nodules. Further north, the road traverses a second valley of elevation, and at the fortieth mile is the signal-tower of Dans Hoogte, standing upon a vein of greenstone.



1. Cradock.
2. Twee Tafel Bergen.
3. Tarka R.
4. Tarka Mountains.
5. Winterberg Peak.
6. Post Retief.
7. Mount Didima.
8. Blinkwater.
9. Mankazan R.
10. Somerset Fort.
11. Fort Beaufort.
12. Dans Hoogte.
13. Kat R.
14. Little Fish R.
15. Great Fish R.
16. Ecca Heights.
17. Ecca R.
18. Graham's Town.
19. Gualana R.

At the further distance of six miles we arrive at Fort Beaufort, originally only a military post, but now a thriving town. It stands in a sort of basin surrounded by picturesque hills, on the right bank of the river Kat, one of the tributaries to the Great Fish river. Its height above the sea is about 1700 feet.

It is immediately to the north of Dans Hoogte that the district begins which has furnished the remains of the remarkable bidental reptiles, the discovery of which has induced me to make the present communication. Many of these are found in the basin of Fort Beaufort, and also at the Mankazan Post, twenty miles from that Fort in a north-easterly direction. The prevailing rock of this district is a slaty sandstone, readily disintegrating, and containing nodules of a greyish-blue argillo-ferruginous limestone, resembling septaria. In these nodules the fossils are found thinly coated with limestone, the bone and its stony matrix being often so thoroughly amalgamated as to render it difficult to distinguish between them. At the Mankazan Post, in the same strata which furnish bidental remains, my friend Mr. Borcherds has lately discovered small bivalve shells. I had not procured specimens of these shells when my collection was shipped for England.

Passing on from Fort Beaufort, you find, at the entrance of the gorge of the Kat river, a bed of greenstone about fifty feet thick, which rests conformably on the stratified sandstone; and this remark applies to all the masses of greenstone on the south of the Winterberg mountain. On quitting the gorge you turn to the north and arrive at the Winterberg new road, which follows the course of the beautiful Blinkwater valley; and in this valley you meet with another bed of greenstone. It was near the Blinkwater Post that, while superintending the construction of the road, I succeeded in extracting from the scarp of a steep hill of sandstone the lower part of the pelvis, a fragment of the bony cuirass, the head armed with sixty teeth, and other bones of a large reptile.

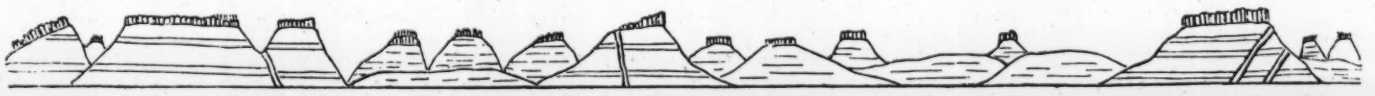
On reaching the first elevated platform of the Winterberg region, another bed of greenstone occurs. This sandstone region, though cold and bleak in winter, is healthy and beautifully verdant, and produces corn and wine in considerable abundance. In this, as in all other sandstone districts of the colony, the water is pure, but the grass is sour; whereas in those districts where argillaceous rocks prevail, the water is brackish, but the grass is sweet. For this reason, the tracts where clay predominates, are greatly preferred for breeding sheep and cattle.

The road, as it ascends above this platform, passes to the west of the lofty and serrated edge of the Didima, which forms the northern boundary of the Hottentot settlement on the Kat river. Near the military station, called Post Retief, a trap dike crosses the road; and as you ascend higher, the dikes increase in number, and the strata of sandstone become intermixed with greenstone. The dip has here diminished to 3°, and it goes on lessening towards the north. The base of the escarpment of the peak of the Winterberg is covered with dense forests of timber. The southern and eastern escarpments of the peak consist of a buff-coloured, soft, stratified sandstone, intermixed with basalt, greenstone and syenite. The summit of the peak is a flat tabular mass of trap, about 6000 feet above the sea.

To form a notion of the geological structure of the singular country which you survey from this lofty eminence, and which forms part of a similar district of great extent, you have to imagine a plain between 500 and 600 miles long from east to west, and about 200 miles broad from north to south, and this plain elevated from 3000 to 4000 feet above the sea. Let there be superimposed on this plain, in some parts long continuous ranges, in others detached table-topped mountains capped with trap, these ranges and mountains rising to a further height of from 500 to 3000 feet. Let all the stratified rocks within this area be perfectly horizontal, and be intersected with a network of trap dikes from eight inches to 100 yards broad, and many of them more than fifty miles long. Such is the character of the country which, at a variable distance from the sea-coast, extends from the Roggeveld, about 1° east of Cape Town, to the Amatembu territory, 8° further to the

eastward; and of this country the portion within view from the summit of the Winterberg presents a correct epitome.

The northern side of the Winterberg is without a vestige of wood, and is less steep than the southern. The Tarka river rises on the descent to the north-west, and after flowing in that direction about thirty miles, and then nearly the same distance to the south-west, (in which course it passes through the extensive level plains, named, after the river, the Tarka plains,) it falls into the Great Fish river. These plains are bounded by a number of fantastically-shaped mountains, among which are the Twee Tafel Bergen, twenty miles north-north-west of the Winterberg peak. In descending towards the military station, called Tarka Post, the peculiar forms of the detached hills, with their basaltic cappings, begin to attract attention. I append an outline sketch of this singular district, representing these cappings formed of huge columns from 50 to 200 feet in height, resting on horizontal strata, and the



basaltic dikes which traverse the strata. If we suppose the whole of these tabular summits to have been once continuous, denudation, in order to reduce them to their present disconnected state, must evidently have operated on a very gigantic scale.

In the Tarka mountains, which may be regarded as a prolongation of the Winterberg range, a calcareous pisolite is found, unfit for lime-burning, owing to the quantity it contains of alumina and oxide of iron.

On the northern side of this range, at Tarka, I found remains of Bidentals; and I made the same discovery in the Graaff Reinet division, nearly 100 miles to the west of Tarka. Moreover I have little doubt, from the recollection I have of some osseous remains which were found some years ago in the district of Beaufort, about 100 miles further westward, that these also belonged to the same group of reptiles.

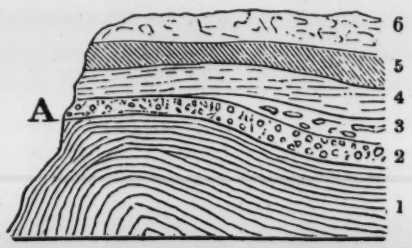
What may be the geological position of the formation containing these reptilian remains is a point not easily determined, in consequence of the difference there is, in composition and external appearance, between the strata of South Africa and the known and described strata of other countries. The difficulty is the greater, from the extremelyrare occurrence of fossil shells; for throughout the whole of the extensive area in which reptilian remains occur, not a single shell has been discovered, so far as my own researches have gone; and except the instance of Mankazan, I know only of one other in which such a discovery has been made. I here refer to an Ammonite, which a friend of mine, dwelling at Cradock, found *in situ*, at the summit of the Spitzkop, or Compass Berg, 7000 feet high, and the loftiest mountain in South Africa; it lies 100 miles west-north-west of the Winterberg peak.

This fossil is now in my possession, and agrees, I believe, with *Ammonites planulatus*. There are, it must be acknowledged, no sufficient data for determining with precision the age of the formation in which the bidental remains are found.

Returning once more to the Winterberg peak as a point of departure, and then passing on towards the north, we arrive, after traversing seventy miles, at the Bambus Bergen, a mountain chain in which the most northerly of the feeders of the Tarka river have their source. After a farther distance of seventy miles, in the course of which we meet with detached hills separated by extensive and dreary plains, we arrive at the magnificent Nu Gariep, or Orange river, in whose bed are rounded pebbles of serpentine, steatite, asbestos, agate, and amygdaloid both of black and white colour; these minerals being entirely different from those which form the materials of the pebbles occurring in the river-beds within the colony. In the country beyond the Nu Gariep, extensive coal-fields have been discovered; and I have received from the neighbourhood of the Modder or Alexander river, which enters the Ky Gariep in south latitude 29°, the head of a bidental reptile*.

I propose in the next place to describe an overlying conglomerate and some tertiary deposits which occur in Lower Albany; after which I shall proceed to notice the detrital deposits of the basin of Fort Beaufort. The conglomerate manifestly consists of the debris of the red quartzose sandstone, described at the commencement of this paper; the debris being cemented together by oxide of iron, which abounds also in the parent rock. The bed lies unconformably on the sandstone and clay porphyry above described [*see the next diagram*], and has not been observed to the north of the northern limit of those rocks; but numerous detached portions of it appear throughout the lower part of the district of Albany. It has not been found to contain organic remains.

Of the tertiary deposits a fine section is displayed on the estate of Mr. Onslow Peché, and is represented in the annexed diagram.



In this sketch, (1) is the underlying quartzose sandstone, on which rests the conglomerate (2); and at the junction of the beds are three caves (A), containing capillary crystals and stalactites of alum. (3) is a soft friable sandstone, containing large masses of fossil wood; and it is covered, first by a calcareous marl (4) and then by a shelly limestone, abounding in shells like those still existing on the South African coasts. The last and uppermost bed (6) is a soft calcareous rock, filled with gigantic oyster-shells. I have reason to believe that tertiary formations similar to these extend all along the coasts, and I hope to enjoy further opportunities of examining them.

* *Dicynodon testudiceps* of Owen. See the next memoir.

A vast diluvial deposit is found in the basin of Fort Beaufort, rising in many places more than 100 feet above the banks of the Kat river. It is made up of fragments of the rocks that compose the neighbouring mountains, the fragments being well-rounded by attrition. A considerable quantity of calcareous tufa, and also of detached calcareous nodules, differing in texture from those occurring in the neighbouring strata, are also present in this deposit. In the lower parts of the basin alluvium is found of considerable thickness. No fossils have hitherto been obtained from either of the above modern deposits.

From an alluvial deposit on the banks of the Modder river, before noticed, there was obtained, about five years ago, the skull of a kind of Buffalo, retaining the bony core of a pair of horns, which it is calculated must have measured full fourteen feet from tip to tip when perfect. This fossil is now in Cape Town.

[N.B. *Professor Owen, in compliance with the earnest wish expressed by Mr. Bain, having undertaken to examine and describe the principal specimens in Mr. Bain's collection, it has not been deemed necessary to publish the original catalogue of specimens which accompanied the foregoing paper.*]

III.—*Report on the Reptilian Fossils of South Africa.*

PART I.—*Description of certain Fossil Crania, discovered by A. G. Bain, Esq., in Sandstone Rocks at the South-eastern extremity of Africa, referable to different species of an Extinct genus of* Reptilia (Dicynodon), *and indicative of a new Tribe or Sub-order of* Sauria.

By RICHARD OWEN, Esq., F.R.S., F.G.S. &c.

[Read January 8th, 1845.]

Plates III. to VI.

BEFORE commencing the present Report, I must express my great obligation to Mr. Bain for the opportunity of studying the extraordinary fossil remains which form its subject, and for the favour which that zealous explorer of South African geology has conferred on me, by coupling, with his transmission of the fossils to the care of the Geological Society, the request that I would undertake their description.

The endeavour to fulfil this request has yielded me the highest pleasure; and here I must state, that it is chiefly by the timely and active assistance of an intelligent workman, skilled in removing from fossil bones their hard adherent matrix, and of Mr. Scharf's well-known artistic ability in preparing the accompanying illustrations of the fossils, so displayed,—aids, which the President, H. Warburton, Esq., M.P., most promptly and liberally, at his own expense, placed at my disposal,—that I have been enabled so soon to obtain the results which are embodied in the present part of my Report.

The most remarkable character of the fossils selected for description is that which their discoverer, Mr. Bain, has indicated by calling them 'Bidentals': viz. the presence of two long, curved and sharp-pointed tusks, which, like those of the Walrus, Musk-deer and Machairodus, descend, one from each superior maxillary bone, and pass on the outside of the fore-part of the lower jaw.

This dental character has hitherto been manifested only by Mammals, and is rare in that class: the species above-cited are almost the only ones which present it as conspicuously as do the African fossils under consideration. The first cursory examination however of these crania, as they originally came into my hands, roughly hewn out of their rocky matrix, which concealed most of their anatomical characters, sufficed to demonstrate that they had belonged to a cold-blooded class of vertebrate animals. In one*, the fore-part of the skull showed the median undivided process of a single 'os intermaxillare' ascending and separating two distinct anterior nasal apertures; in a second†, the boundaries of a much-contracted cranial box were traceable; both characters combined to prove that the animals to which these fossil skulls belonged had been air-breathing, oviparous and cold-blooded,—in short, *Reptilia*; but members, in this class, neither of the Crocodilian nor Chelonian orders.

No mammiferous animal has the intermaxillary bone single, or the external bony opening of the nasal cavity double: neither Mammal nor Bird has the cavity for the brain so small in proportion to the skull as in the fossil referred to. All Crocodilians, fossil as well as recent, have the intermaxillary bones divided by a median suture, and the anterior nasal aperture single and in the median line, as in Mammals: in all Chelonians the same aperture is single, and perforated in the middle of the fore-part of the skull, just where the specimen with this part most entire and most resembling in its general outward form that of a Tortoise (*Dicynodon testudiceps*), presents the convex, imperforate, ascending median plate of the broad intermaxillary bone. Fishes were out of the question, they having no well-defined external respiratory inlets to nasal passages.

* *Dicynodon testudiceps*, Pl. V. † *Dicynodon lacerticeps*, Pl. III.

The Lacertine Sauria offered all the characters which could be distinguished in the partially unshrouded fossils; but the single intermaxillary bone and the double nostrils being likewise present in most Ophidians and a few Batrachians, it became necessary to inspect and compare more closely and extensively the anatomical characters of the fossil crania in question in order to determine precisely their immediate affinities.

My first task, therefore, was to supervise the chiselling away of the extremely hard and adherent sandstone which covered almost every part of the surface of the skulls about to be described.

The large and immoveably articulated superior maxillary bones, the strong and complete zygomatic arch continued thence to the tympanic bone, were decisive against the Ophidians and Batrachians; few indeed of the existing Lacertians manifest these characters so strongly developed as they were in the fossils: yet other structures were brought to light, as the vertically-descending tympanic pedicles, suspended by their upper extremity from the junction of the zygomatic and mastoid bones, which added important evidence to the nasal and intermaxillary characters in proof of the essential relationship of the bidental Reptilia to the Lacertian order.

The broad and almost entire plate of bone, continued vertically down from the bifurcated parietal to the occipital foramen, now so clearly displayed in the skull of the *Dicynodon lacerticeps* (Pl. IV. fig. 2.), was, however, a cranial modification only presented by the Crocodilia in the existing class of Reptiles; but the minor deviations from the ordinary Lacertian structure are so numerous, the mode in which Crocodilian and Chelonian characters are interwoven upon an essentially Lacertian base is so interesting, and the individual and distinctive characters of the Dicynodons so striking and peculiar, as to require for their illustration a detailed and consecutive osteological description of the specimens at present worked out, in which I shall indicate, as I proceed, the affinities illustrated by such characters.

Sufficient has been said to demonstrate at least the generic distinction of the ancient Reptilia of the African sandstones, which were armed with two canine tusks; and postponing for the present the consideration of the claims of the different species here determined to subgeneric rank, which are most likely to be established when the entire skeleton is brought to light, I shall provisionally include them all under the generic name of *Dicynodon**.

* From δὶς, *two*, and κυνόδους, a term applied by Hippocrates to the *canine teeth*, and expressing the same idea as their common English denomination. The two teeth, which are so largely and exclusively developed in the present most extraordinary Reptilia of ancient Africa, answer to the canines of Mammalia.

Dicynodon lacerticeps.

Commencing with the most perfect of the fossil skulls* which have at present been worked out of the hard matrix, the longer and narrower facial part which it presented, in comparison with the others, suggested to me the term '*lacerticeps*,' lizard-headed, for the species to which it belonged.

The occipital region of this skull (Pl. IV. fig. 2.) is well-preserved, and is formed by a moderately broad, triangular, vertical, continuous wall of bone, overhung by an angular horizontal ridge, about half an inch in breadth, and shaped like the penthouse of a gable-end; this ridge is formed by the supra-occipital (4), the parietal (8), and the mastoid (7) bones.

This character is peculiar, as has been already observed, to the Crocodilians among existing Reptilia. The Chelonians all present a strong and long spine developed backwards from immediately above the foramen magnum. The Lacertians and Ophidians have two wide vacuities in the occipital region over-arched by the elongated mastoids, which in Serpents are prolonged backwards. In the Batrachians the low and narrow occipital region slopes directly forwards from the great foramen, and presents also another and more decisive difference in the two condyles for the articulation of the head with the vertebral column and their lateral position in respect of the occipital foramen.

This foramen (*m*) in the *Dicynodon lacerticeps*, is vertically oval, with the large end downwards: its lower fourth part is bounded by a single subhemispherical, convex, articular condyle, which was partly broken away in the specimen. The upper angles of the condyle are separated by a smooth depression from two small obtuse prominences, projecting one on each side the middle of the great foramen, immediately below the suture which divides the ex-occipitals (2, 2) from the supra-occipital (4).

On the fractured surface of the occipital condyle we perceive two fine lines of the matrix, commencing from near the middle of its upper border which forms the lower part of the foramen, and diverging as they descend, dividing the osseous substance of the prominence, like veins traversing a rock, into three equal parts. These veins of matrix mark the sutures between the basi-occipital (1) and ex-occipitals (2, 2), which three elements enter, in the same proportions, into the formation of the condyle as in the existing Lizards.

In the Crocodiles the single condyle is formed almost exclusively by the basi-occipital, and its upper angles are not continued upon the sides of the foramen. In the Chelonians the three elements of the occipital bone contribute to form the condyle, as in Lizards and the Dicynodon; but they project backwards from the

* Plates III and IV.

floor of the cranial cavity before forming the articular convexity, which constitutes no immediate part of the circumference of the foramen magnum (*m*). The shape of the foramen itself in the Chelonians is more like that of the Dicynodon than it is in the Lizards. In the Chelonians the lower three-fourths of the foramen is formed by the ex-occipitals; in the Crocodilians the upper three-fourths. In the Dicynodon the basi-occipital (1) forms a very small part of the lower border of the foramen; the ex-occipitals (2) constitute the rest of its lower half, and it is completed above by the broad and high supra-occipital (4). In the Crocodilians this element is excluded from any share in the formation of the foramen magnum. The Dicynodon, therefore, in the essential anatomical characters of the occipital region of the skull, and in its shape, chiefly due to the angle formed by the overhanging parieto-mastoid ridge, adheres to the Lacertian type; but in the extent and ossification of this region it resembles the Crocodilia. It is not, however, devoid of characteristics peculiar to itself: the broad semicircular lower half of the occiput sends out a series of short and thick, equidistant processes, like rays. Two (l', l') are continued downwards and a little outwards from the infero-lateral parts of the basi-occipital: above these the longer and stronger par-occipital processes (3, 3)* extend outwards and a little downwards to abut against the lower ends of the tympanic pedicles: the next process ($2'$) above is a narrower and shorter one, which projects from the upper and outer angle of the par-occipital into the interspace separating it from the tympanic bone; but, apparently, without effecting a junction with that bone: the fourth radiating process ($4'$) on each side forms the lower prominent angle of the triangular supra-occipital plate, and abuts against the mastoid bone. The condyloid foramen ($2''$) is large, and is pierced on each side of the single condyle; not, as in the Crocodiles, above that prominence.

In commencing the examination and comparison of the upper region of the skull of the Dicynodon (Pl. III. fig. 2.), we cannot fail to be struck with the very contracted form of the cranium proper (8, $8'$), which is scarcely more than two-thirds the breadth of the inter-orbital space. It reminds one of the lowest Batrachians; but the temporal vacuities (t, t), on each side, are divided by a strong bridge of bone from the orbits, which is not the case with the Batrachians. This transverse bar or bridge is chiefly formed by the post-frontals (11, 11), which are not produced backwards, as in most Lizards: neither do the mastoids (7, 7) join the post-frontals to overarch any part of the temporal spaces, as in the Crocodilians; but they are confined to the posterior circumference of those spaces, which are bounded or over-arched laterally by a single bridge, formed chiefly by the zygomatic

* These (*occipitaux externes*, Cuv.) are not divided by a suture from the ex-occipitals (*occipitaux latéraux*) as in the Chelonia.

or temporal bones (27, 27). In the strength of these bones and their continuation from the lower part of the post-orbital wall, the Dicynodon much more resembles the Crocodilians, especially the extinct forms, than it does the Lacertians: the zygomatics are nevertheless continued, as in most Lacertians, to the upper, and not to the lower end of the tympanic pedicles, as they are in the Crocodiles.

In some existing Lacertians, as the Acrodont species figured*, the temporal vacuities are over-arched by two bony bridges extended in the axis of the skull, one from the upper angle of the orbit, formed by the post-frontal and mastoid, to the upper end of the os tympanicum; the other from the lower angle of the orbit, formed by the malar and zygomatic, to the lower end of the os tympanicum. This is essentially a repetition of a Crocodilian structure; the extinct *Teleosaurus* most resembling the Lizard cited in the length and slenderness of the two bridges. The *Rhynchosaurus* of our own new red sandstones seems to have presented the same structure; but part of the lower or zygomatic bridge is broken off in the only specimen of the skull of that genus I have hitherto seen. The exact shape and vertical extent of the strong single bridge formed by the zygomatic and mastoid, in the Dicynodon, cannot be determined in the present fossil, in which the upper border is broken away. In the formation and position of the single zygomatic arch, the Dicynodon most resembles the genus *Testudo*; only the arch abuts against a smaller proportion of the upper and anterior border of the os tympanicum in the bidental fossil.

The part of the single narrow parietal bone which separates the temporal fossæ from each other is impressed on each side by an oblique smooth tract, indicating the origin of the strong temporal muscle; the upper boundary-ridges of the tracts almost meet along the posterior half of the parietal, but diverge as they advance forwards and curve outwards to be continued upon the post-frontals. The intermediate flat, triangular space of the parietal included by these diverging lines is perforated by a small elliptical foramen: this character of the parietal bone is peculiar, amongst existing Reptiles, to the Lacertia, though far from being constant in that order: it appears to have been present in the skull of the extinct *Pistosaurus*. The relative position of the foramen is the same as in the *Rhynchocephalus* figured and in the great *Monitor Javanicus*†, behind the transverse sagittal suture; not, as in the *Iguana*‡, upon that suture. The posterior part of the parietal bone of the Dicynodon expands and bifurcates; this is also a peculiarly Lacertian character. The extremities of the parietal forks (8′, 8′) unite with the strong mastoids (7, 7), which receive the extremities of the zygomatics (27), and form, with them, the medium of attachment of the tympanic pedicles to the cranium. These are strong bones

* Pl. VI. figs. 5, 6, 7.

† Cuvier, Ossemens Fossiles, 4to, 1824, vol. v. part 2. pl. xvi. fig. 7.

‡ Ib. fig. 23.

(28) descending from the above attachments with a sigmoid curve in a vertical direction, with a slight inclination forwards. They are relatively stronger than in most Lizards, but are less robust and longer than in the Crocodilians or Chelonians, in which the tympanic pedicles are wedged immoveably into the interspace of surrounding bones, and in the Crocodilia extend obliquely downwards and backwards. The position of the tympanic pedicles, and their comparatively free suspension, are very characteristic of the Lacertian affinities of the Dicynodon. They terminate below by a broad and slightly convex condyle, looking downwards and forwards, for articulating with the lower jaw, and near this part receive abutments from the par-occipital and sphenoid bones.

The form of the temporal fossæ (*t*, *t*) is a wide oval, with its long axis almost parallel with that of the skull. The orbits (*o*, *o*) are large and almost circular, with a complete bony frame or boundary. In the present species (*D. lacerticeps*) they are relatively as large as in most Lizards, and larger than in the Crocodiles. Their position, equidistant from both ends of the skull, is also a Lacertian character: in the Crocodiles the orbits are nearer the back part, in the Chelonians they are nearer the fore-part of the skull.

The inter-orbital part of the surface of the skull is one-third broader than the inter-temporal region, or true cranium, and gradually expands as it extends forwards. The contour of this part of the skull descends into the nasal region by a gentle convex curve (fig. 1.): the surface is a little depressed along the middle, and rises into a slight protuberance at the fore-part of the supra-orbital boundary, which is formed by the pre-frontal (14). The mid-frontal (12) is divided by a median suture, as in the Varanian Lizards and the Chelonia: it is a single bone in the Crocodiles. In the Dicynodon, as in the Iguanas and American Monitors (*Thorictes*, *Tejus*, &c.), the mid-frontal forms the middle two-thirds of the supra-orbital ridge: the posterior part of this ridge and the upper half of the posterior rim of the orbit are contributed by the post-frontal (11), which forms the medium of union between the mid-frontal, parietal, malar and zygomatic bones. The malar (Pl. III. fig. 1, 20*a**) and superior maxillary bones (20) appear to be indistinguishably blended together below the orbit, where they swell out in an unusual degree, and carry the floor of the orbit much beyond the roof; turning the aspect of the plane of the orbit obliquely upwards and outwards, as in the Crocodiles, and rendering it less vertical than in most Lizards. The fore-part of the orbit is bounded by the lachrymal bone (16), which is extended upon the face, apparently as far as to the back part of the nostril, in the present species. A single moderately large lachrymal foramen

* The dotted angular line in front of 20 *a* indicates the position of the hollow base of the canine tusk, not a suture.

(fig. 2, *l*) is pierced just within the brim of the orbit, and defended by a protuberance of the lachrymal bone in front of it.

The bony anterior apertures of the nasal cavity (*n*) are separated above by a space two-thirds of an inch in breadth, and formed principally by the nasal bones, between the anterior ends of which, the median ascending process of the intermaxillary bone is wedged. The shape of the nasal openings (*n*) is a longitudinal ellipse; they are situated about half an inch in advance of the orbits, are defined above by a sharp overhanging border of the nasal bones, and the lower boundary, which is formed by the superior maxillaries (20), is rounded off into the nasal cavity: the plane of the opening being much nearer the perpendicular than is that of the orbit. In the Crocodiles the plane of the single median bony nostril is horizontal; in the Chelonia it is nearly or quite vertical; in the Lizards the nostrils are double; and in many, as *Uromastyx* and *Rhynchocephalus*, are as lateral in position and aspect as in the Dicynodon. A very remarkable feature of the present fossil cranium is the swelling out of the superior maxillary and malar bones below the orbits, which part is the *point d'appui* of four strong bony columns: one of these is formed by the lachrymal (16) and pre-frontal (14) and descends in front of the orbit; a second, formed by the malar (20 *a*) and post-frontal (11), descends behind the orbit; the third, formed by the zygomatic (27), extends longitudinally from the back part of the malo-maxillary protuberance to the tympanic pedicle; the fourth, contributed by the 'os transversum,' is continued from the under part of the maxillary bone, anterior to the orbit, downwards, backwards and inwards to abut against the pterygoids. The superior maxillary bone commences anteriorly by a suture, very distinctly shown in a specimen of the fore-part of the cranium of the *Dicynodon testudiceps**, which extends down from the nostril to the alveolar border of the upper jaw; the bone extends backwards, forming the lower border of the nostril, and uniting with the lachrymal bone, as it passes to the lower part of the orbit; then expanding rapidly, as it proceeds, to coalesce with the malar bone. This expanded suborbital part of the maxillary bone or malo-maxillary bone, supported by the four converging stout osseous columns above described, is excavated by a wide and deep conical alveolus, with a circular area of equal diameter,—half an inch,—to its closed base, and lodging a long and strong, slightly curved and sharp-pointed canine tooth or tusk, which projects about two inches from the open extremity of the produced socket. The direction of the tusks is forwards, downwards and very slightly inwards; the two converging, as they descend along the outer side of the compressed symphysis of the lower jaw. The fractured state of the fore-part of the present fossil cranium anterior to the nostrils prevents the

* Pl. VI. fig. 1.

recognition of its exact form and extent, and also the more important determination of the structure of the intermaxillary bone (19). This deficiency is, however, amply compensated by the perfect state of the fore-part of the skull of the allied species, *Dicynodon testudiceps*; in the description of which, the affinities deducible from the modifications of the intermaxillary and palatal regions will be more fully discussed.

I may observe however, that in the present specimen of the *Dicynodon lacerticeps*, the fore-part of the upper jaw has been longer and more compressed than in the other recognizable species of the bidental genus, and that no trace is perceptible of any other teeth than the two long canine tusks above described. It is evident that the carcase of the old reptile to which the skull in question belonged must have been buried in the sand, which subsequent consolidation converted into the present hard matrix, soon after death, and there have rested undisturbed until its discovery by Mr. Bain: for the lower jaw has not suffered the smallest dislocation from its natural junction with the extremities of the tympanic pedicles; and this is not a joint where there is close interlocking of the opposed surfaces of the bones, as in the mandibular articulation of the Badger and some other Mammalia. A shallow cavity, cut obliquely in the posterior part of the lower jaw, receives the corresponding slight convexity at the end of the tympanic pedicle. Thus attached, the lower jaw has been cemented by the surrounding rock in its natural position, but with the mouth a little open. The skull of the *Rhynchosaurus** from the new red sandstone at Grinsill near Shrewsbury has the lower jaw similarly preserved, showing the same speedy entombment and subsequent undisturbed repose in that triassic matrix.

The lower jaw manifests by its great depth as compared with its length, and by its edentulous condition, a close and important relationship between the Dicynodon and *Rhynchosaurus*; but this part of our ancient African Lacertian deviated still further from the ordinary proportions of the lower jaw in the Crocodiles and Lizards, and more closely resembled that of the Tortoises and Turtles, in being still shorter in proportion to its depth than in the Rhynchosaur: it appears, however, to have differed from the lower jaws of all other known recent and extinct Reptiles, by the evident traces of a strong longitudinal ridge projecting outwards from the middle of the external surface of each ramus. A feeble rudiment of such ridge is present in the lower jaw of the *Rhynchocephalus* figured, and is developed, as in the Dicynodon, from the dentary piece. There is no trace of teeth or their sockets in the lower jaw of the *Dicynodon testudiceps*: so much of the alveolar border as is exposed presents a smooth and even edge, which seems to have played like a scissor-blade upon the inner side of the corresponding edentulous border of the upper jaw; and it is

* Report of British Association, 1841, p. 145.

most probable, from the analogies of similarly shaped jaws of existing Reptilia, that the fore-part of both the upper and under jaws were sheathed with horn.

Amongst existing Reptilia, the Siren alone combines this structure with true teeth: but these are minute and numerous, and disposed upon the palate in the upper jaw, and upon the opercular piece of the lower jaw: in other respects the cranial structure of the Siren is as remote from that of the Dicynodon as can well be in any Reptile, if we may be permitted so to call the Siren. It is the chief and best-known characteristic of the Turtles and Tortoises to have the jaws sheathed with horn, as those of the Dicynodon appear to have been; but no known member of the *Chelonian* order has any true teeth*. Until the discovery of the *Rhynchosaurus*, this edentulous and horn-sheathed condition of the jaws was supposed to be peculiar to the Chelonian order among Reptiles; and it is not one of the least interesting features of the Dicynodon of the African sandstones, that it should repeat a Chelonian character, hitherto peculiar, amongst Lacertians, to the remarkable extinct edentulous genus of the new red sandstone of Shropshire: but our interest rises almost to astonishment, when, in a Saurian skull, we find superadded to the horn-clad mandibles of the Tortoise a pair of tusks, borrowed as it were from the Mammalian class, or rather foreshowing a structure, which in the present existing creation is peculiar to certain members of the highest organized warm-blooded animals.

The Reptilian nature of the Dicynodon is not more strongly evidenced by the characters of the cranial and facial bones, than by the compound structure of the lower jaw: that attached to the skull of the *Dicynodon lacerticeps* has had most of its exterior surface splintered and broken away: a portion of a detached lower jaw of apparently the same species of Dicynodon shows the entire anterior end, and gives the two sections 5 and 6 in Plate IV. But, before speaking of the traces of the sutures thus exposed, the general form of the lower jaw may be more particularly noticed (Pl. III. fig. 1.). It gradually increases in depth from the posterior articulation forwards to the symphysis, which then expands more suddenly in the vertical direction and curves slightly upwards; the rami converge at a very acute angle in approaching that part, and suddenly bend inwards at their lower border to join and form the symphysis (Pl. IV. fig. 4, 24), at a distance of three inches and a half from the posterior articulation; the whole length of the lower jaw being four inches and a half, perhaps five inches, including the posterior angle, which in the present example is broken away on both sides. The depth of the ramus immediately in front of the articulation is nearly one inch; at the middle of the ramus it

* In the *Trionyx* rudiments of teeth are present in the embryo, and this is probably the case in other Chelonia; but they are numerous, equal, and very minute. See my 'Odontography,' p. 179.

is one inch and one-third; at the fore-part of the symphysis it seems to have increased to the depth of two inches, but the apex is broken away. The lower border of the jaw is slightly concave: the angular process appears to have been continued but a very little way beyond the articular cavity, which is excavated on the posterior surface, sloping from the coronoid eminence backwards to the angle. That eminence, which is developed from the coronoid or complementary piece (26 *a*), is low and long, and rises behind the middle of the ramus. A strong ridge projects from the outside of the jaw, extending along the middle third of the ramus, equidistant from the alveolar and the lower borders of the jaw (Pl. IV. figs. 3 & 6, 24). Anterior to the coronoid the upper border of the jaw rises with a gentle concave curve as it advances forward to meet and join the opposite border at the upper extremity of the strong and vertically extended symphysis: the fore-part of the symphysis is convex from side to side, three-fourths of an inch broad, and slopes from below upwards and forwards with a gentle convex curvature, without any trace of median suture. It is divided by a slight ridge on each side, externally, from the concavities receiving the tusks when the mouth is closed.

On the right side of the lower jaw, attached to the cranium, the posterior pointed extremity of the fractured remains of the angular piece (Pl. III. fig. 1, 26), may be clearly traced, terminating about half an inch in advance of the glenoid articulation: this is supported by the articular piece (25), which forms exclusively the small angular process behind and below the joint for the attachment of the digastric muscle. The outer wall of the left ramus is broken away so as to expose the outer surface of the anterior part of the articular piece, which extends forwards upon the inner side of the ramus in a pointed form nearly half-way towards the symphysis, where it joins the opercular or splenial piece, 25 *a*.

The sur-angular extends from the articulation forwards, beneath the large complementary or coronoid piece, terminating gradually in a point between that and the dentary. It is cut across near this extremity at 25 in fig. 6. Pl. IV.; and the trihedral form of its thicker posterior part is shown at 25 in fig. 5.

The coronoid or complementary piece, 26 *a*, is a large bone, forming the upper border of the middle two-thirds of the ramus. It commences by a point posteriorly, which rests upon both articular and sur-angular pieces; gradually enlarges, chiefly in the vertical direction, as it extends forwards; is grooved upon its upper thin border, and more widely and deeply excavated below, where it receives the tapering anterior extremity of the sur-angular: both grooves are shown in the section Pl. IV. fig. 6, through near the middle of the ramus at 26 *a*: the slender posterior end of the coronoid piece is cut through at 26 *a* in fig. 5. The angular piece, which forms no part of the angle of the jaw in Dicynodon any more than it does in modern Lizards, extends from beneath the articulation along the lower border of the jaw, increasing

in thickness and forming an angular groove on its inner side, as shown in the section through the posterior third of the ramus at 26, fig. 5. Pl. IV., joining the splenial element 25 *a* by its lower inwardly inflected border. At the middle of the ramus it presents an angular excavation on its outer part, pointed behind for the reception of the lower pointed branch of the dentary piece, and increases in depth as it diminishes in thickness, forming the thin plate on the inner side of the dentary piece, exposed in the middle section, fig. 6, 26; the lower border of the angular there curving inwards and forming a groove for the reception of the lower border of the splenial element 25 *a*, which presents two grooves for the reciprocal reception of the edges of the single groove in the angular piece, the two elements being there doubly interlocked together. The dentary piece, which forms the whole of the strong and large simple symphysis, commences in each ramus behind by a bifurcate extremity, the upper fork reaching to the posterior third of the ramus: it is shown at 24 in the section through that part. It there joins the sur-angular (25), and increasing in thickness as it advances forward soon joins the coronoid, and now takes on a trihedral form as in fig. 6, 24, the outer angle forming the strong outer ridge before described: it also increases in depth, and at the last section the upper and lower forks have united; the lower fork forming the thin plate of bone applied to the outer side of the angular piece, and fitting into the angular notch in that bone. About half an inch anterior to the bifurcation, the portions of the dentary in each ramus unite to form the symphysis, which has already been described, and which shows no trace of median suture. A considerable vacuity occupies the substance of each ramus, bounded at the middle of the ramus, as shown in section fig. 6, by the dentary and angular pieces externally, by the splenial and coronoid pieces internally, by the sur-angular and coronoid above, and the interlocked opercular and angular pieces below. This vacuity communicates with the external surface in the form of a narrow elongate fissure, bounded anteriorly by the two forks of the dentary, and behind by the upper fork of the dentary, the sur-angular and the angular pieces. This fissure appears to have been closed on the inner side of the ramus by the splenial or opercular piece.

The alveolar border of the lower jaw is slightly grooved, as in the *Trionyx*; the outer border of the groove being most produced, and forming the trenchant edge. In the edentulous character of the alveolar border, in the anchylosed symphysis, in the depth of the rami and its general form, the lower jaw most resembles that of the Chelonian Reptiles. In the external fissure above described, and the posterior bifurcation of the dentary piece, it resembles the lower jaw of the Crocodile; but in the more essential characters of its composition it agrees more closely with the Lacertian type of the same bone. Thus the angle of the jaw is formed by the articular, not by the angular piece, as in the Crocodile: the coronoid or

complementary piece, instead of the insignificant size to which it is reduced in the Crocodiles and most Chelonians, presents proportions surpassing those of most Lacertians: the upper margin for the attachment of the temporal muscle is intermediate in height between that in the Crocodiles and the more angular elevation of the coronoid in most Lizards. In the proportion of the dentary to the other elements of the composite bone, the Dicynodon resembles the Lacertians, the dentary piece forming a much larger proportion of the lower jaw in the Crocodiles and Chelonians; but the entire structure of the bone exemplifies, as remarkably as the rest of the skull, the singular engrafting of Crocodilian and Chelonian characters upon an essentially Lacertian basis.

Dicynodon testudiceps.

The specimen on which the above-named, or tortoise-headed, species of Dicynodon is founded is the anterior two-thirds of a skull, without lower jaw; including the nostrils, the orbits and the bony palate, with the anterior and posterior palatal apertures (Pl. V. & Pl. VI. fig. 1.).

It differs in a readily appreciable and well-marked degree from the last-described skull of the *Dicynodon lacerticeps*, by the greater breadth and less length of the facial part of the skull, by the smaller orbits and larger nostrils, and by the greater declivity of the contour of the internasal and intermaxillary regions. In *D. lacerticeps* (Pl. III. fig. 1.) the profile of the internasal plate is continued from the inter-orbital region, with a slight declivity, almost straight to the intermaxillary bone. In *D. testudiceps* (Pl. VI. fig. 1.) the profile bends down directly from the inter-orbital region, and rapidly descends to the edentulous border of the intermaxillary bone. The distance from the posterior border of the orbit to the anterior border of the nostril is rather less in the *Dicynodon testudiceps* than it is in *D. lacerticeps*; but the breadth between the supra-orbitary ridges in *Dicynodon testudiceps* is greater, being one inch and two-thirds, and that between the supra-nasal ridges is one inch. The general size of the two fossil skulls compared must have been nearly alike: their specific difference will be obvious from the comparisons above made: the generic identity of the shorter and broader-headed species is shown by the bases of the two large tusks which remain in the sockets of the expanded maxillaries, their exserted crowns having been broken off (Pl. V. fig. 1, *c*).

The breadth and shortness of the skull, the sudden convex declivity of the rostral part, and the sharp vertical, edentulous border of the wide intermaxillary bone, are features of resemblance to the skull of the Tortoise which would at once strike the anatomist acquainted with the peculiar form of that part of the skeleton of the Chelonian Reptile; and they have suggested to me the specific name proposed for the present species. But differences of a more essential nature present them-

selves when we come to a closer comparison. Where the orbits look out from the Tortoise's skull, the anterior nostrils open in that of the Dicynodon: where the single nostril is perforated in front of the skull of the Tortoise, we find a broad, convex, solid wall of bone in the Dicynodon.

The resemblance to the Tortoise is due merely to modifications of proportion and shape of the bones; in the essential anatomical structure of the skull, the present fossil agrees with the more complete skull of the *Dicynodon lacerticeps*: and seeing in both the same aspect of the orbits, the same lateral position of the two distinct nostrils, the same expansion of the maxillary bones with their singular dental weapons, we may safely conclude, that the parts which are complete in the skull of one species must have differed from those which are mutilated or wanting in the other species, only in their form and proportion, and not by any essential anatomical modifications. With this conviction, the entire and well-preserved intermaxillary and palatal region of the skull of the *Dicynodon testudiceps* gives important additional evidence of the nature and affinities of the extinct genus.

All the Crocodilia retain the median suture of the intermaxillaries; most of the Chelonia likewise retain it*: in neither order is there any median ascending intermaxillary process. The Ophidians and most of the Lacertians (all of them according to Cuvier)† possess a single intermaxillary bone, which sends a median process upwards to the interspace dividing the nostrils. In these orders the type of the intermaxillary bone of the Bird is foreshadowed, but the size of the bone is very diminutive as compared with Birds.

In the portion of the skull of the *Dicynodon testudiceps* the whole extent and structure of the os intermaxillare (19) is clearly displayed: there is no trace of median suture on either the external or palatal portions of the bone: it has a median 'branche montante,' which, at the middle emargination of its upper sinuous border, receives the extremities of the nasal bones (15): as it descends from the internasal space it expands, and at the fore-part of the lower border of the nasal aperture meets and joins the superior maxillary bone. The Dicynodon, by the superior size of the intermaxillary bone, pushes the resemblance of its cranial organization to that of Birds much further than do the other Reptilia with the same undivided condition of that bone. I may here however remark, that some of the ancient Saurians, more especially the marine forms, are remarkable for the greater proportion of their divided intermaxillaries than is manifested by the modern Crocodilia. The inferior trenchant border of the intermaxillary bone in the *Dicynodon testudiceps* describes nearly a semicircle horizontally, between the sutures with the maxillary bones (Pl. V. fig. 1, 20). The middle part of the edentulous border is a little produced and

* *Chelys* presents a very small, single, undivided intermaxillary.

† Leçons d'Anat. Comparée, ed. 1837, tom. ii. p. 531.

strengthened by two short and narrow buttresses of bone on the inner side, 19′, dividing that part of the wall of the mouth into a narrow and deep median depression and two wide and shallow lateral depressions, bounded posteriorly by the inward prominence of the sockets of the great maxillary tusks.

A second and more peculiar feature of the palatal region is a longitudinal ridge, formed by the vomer (13), which descends from the middle line, commencing one inch behind the anterior border of the intermaxillary, and after an extent of one inch and a half, subsiding close to the fore-part of the posterior nasal aperture. The vomerine ridge, at its middle part between the sockets of the tusks, is about half an inch in depth: it must strengthen the palatine vault or arch of bone, just as similar appendages of a Gothic roof are introduced to give additional strength as well as ornament. We may therefore regard this structure, which I have not observed in any recent Saurian, as physiologically related to the uses of the tusks of the Dicynodon.

There are no clear or well-defined traces of anterior palatine apertures in the present fossil; an unbroken vault of bone seems to extend from the edentulous border of the intermaxillary and the great maxillary alveoli to the single median vacuity (*p*′), which I take to be the posterior outlet of the nasal cavity. This is of an oval form, one inch two-thirds long, one inch broad, with the great end behind: there is a shallow longitudinal depression on each side of the fore-part of the aperture; the inner border of the depression, formed by the palatine (21) and ento-pterygoid is produced into a ridge, but supports no teeth; the outer boundary of the depression is formed by apparently the os transversum or exo-pterygoid (23), which thence extends outwards and forwards to abut against the back part of the alveolar border of the maxillary. In the place of the depressions, we find in some Lacertians, as *Varanus niloticus*, perforations, corresponding with the larger vacuities in the same part of the palate in the Crocodilians. If, as appears from the carefully exposed palatine surface of the fossil under description, that surface is imperforate anterior to the large median aperture (*p*′), the condition of the bony palate is essentially the same as in the genera *Testudo* and *Chelone*; but the anterior, imperforate tract of bone is much more extensive in Dicynodon. In some *Emydes*, and in *Trionyx*, where the palatal bony roof is of greater extent, it is perforated by an anterior median aperture just behind the intermaxillary border. An analogous aperture is present in the Crocodilians, which is indubitably not the case with the Dicynodon.

The palate of all the existing Lizards that I have examined or found figured in books, presents two anterior palatal apertures besides the single large median posterior vacuity; and most of them have likewise two lateral vacancies, bounded internally by the vomerine and palatine bones, externally by the maxillary bones: the *Varani* have, besides, the pterygoid lateral perforations. Of none of these cha-

racters can I detect any trace in the specimen before me. I am disposed therefore to conclude, that the resemblance to the Chelonian type of cranium, so strikingly exemplified in the edentulous lower jaw and intermaxillary border, may have been extended to the composition of the bony palate.

Returning to the upper surface of the portion of skull under consideration (Pl. V. fig. 2.), we find the region between the upper border of the ascending process of the intermaxillary and the middle of the inter-orbital space formed by a broad rhomboidal tract, including the nasal, 15, pre-frontal, 14, and part of the mid-frontal, 12, bones: the median suture dividing the latter is discernible. The rhomboidal tract has a more unequal surface than the corresponding narrower part of the skull of the *Dicynodon lacerticeps*: the prominences developed from the pre-frontals at the anterior part of the orbits are more marked, and they are divided by depressions from an intermediate prominence at the middle of the tract. The inter-orbital tract is traversed by two longitudinal shallow channels, divided by a median gentle longitudinal rising, and bounded laterally by the raised supra-orbital ridges.

The back part of the cranium has been broken away from the present skull through the parietal foramen, and just behind the commencement of the smooth depressions that mark the origins of the strong temporal muscles (*t*, *t*). The thickness of the parietal bone at this part is nearly half an inch; such strength of the cranial bones is both a Chelonian and Crocodilian character. The orbits, *o*, have a smaller vertical diameter than in the *Dicynodon lacerticeps*; their lower boundary is thick and rounded off; a gradually widening and nearly flat floor of the orbit extends obliquely inwards, downwards and backwards; the lower boundary of the orbit extends straight, outwards and backwards, for two inches; forming, at the fractured end, the beginning of the zygomatic arch, but showing no tendency to curve upwards here, to form the posterior boundary of the orbit, nor any mark of union with such a boundary: if this boundary was completed, as is probable from the analogy of the preceding specimen, posterior to the fractured part of the zygomatic arch, the antero-posterior diameter of the orbit must have been both absolutely and relatively greater than in the *Dicynodon lacerticeps*. The *Crocodilia* and *Ophidia vera* have no bony floor to the orbit: most *Lacertia* and *Chelonia* have that structure, but it is much closer to the palate than in the Dicynodon. The expansion of the malo-maxillary bone both vertically and transversely, to form the socket for the tusk, gives a peculiar form and development to the under part of the orbit of the bidental Reptiles of the African sandstones, which will be readily appreciated by comparison of the present specimen or the figures (Pl. IV. & V.), with the skull of any existing Reptile; it will be seen, however, that it is merely an adaptive modification, in subordination to the support of the tusks, which gives so mammalian a character to this part of the skull of the Dicynodon.

Dicynodon (?) strigiceps. (Pl. VI. figs. 2 & 3.)

This species is founded on the anterior or rostral part of a skull of a Dicynodon(?), which, in proportion to its height and breadth, is as much shorter than that of the *Dicynodon testudiceps*, as this is in comparison with the skull of the *Dicynodon lacerticeps*. The breadth of the inter-orbital space is equal to that in the *Dicynodon lacerticeps*, but it is more concave; it is less than that of the *Dicynodon testudiceps*, and there is no median longitudinal rising, as in that species. The breadth between the upper and posterior part of the nostrils is equal to that in the *Dicynodon testudiceps*; but the rostral contour, continued from the horizontal inter-orbital tract, describes, in descending, a semicircular curve, convex forwards, and with the lower part bending back to form the alveolar, or rather edentulous trenchant anterior border of the mouth.

This form of muzzle not only distinguishes the present species from its congeners, but is unique in the Reptilian class. The orbits, *o*, fig. 2, with prominent anterior borders, are thus brought close to the fore-part of the head; the nostrils, *n*, instead of being in front of the orbits, are beneath them: the physiognomy of the old reptile must have resembled that of the Owl, with its horny beak curving downwards and backwards from between the advanced staring eyes; and I have indicated this resemblance by the proposed specific name. The outer surface of the convex internasal ascending process of the intermaxillary is smooth, entire, showing a slight median longitudinal prominence: the peculiarly shortened muzzle of the *Dicynodon strigiceps* cannot be the effect of accidental fracture, for this would have carried away the fore-part of the alveolar border of the intermaxillary bone, and have left a vacuity between the lateral borders; but the anterior boundary of the palate is complete, fig. 3. This boundary does not describe so true a semicircle as in the *Dicynodon testudiceps*, but is semi-elliptic, being narrower across the commencing expansions, *c*, *c*, apparently of the alveoli, in proportion to the distance from that transverse line to the fore-part of the alveolar border. The reverse of this might have been expected from the extreme shortness of the muzzle, but it is due to the more posterior position of the thickened parts of the superior maxillary bones in the *Dicynodon strigiceps*. In the two preceding species the tusks project from beneath the fore-part of the orbit, or between this and the nasal opening: if the present species possessed the tusks, they must have projected opposite or from beneath the back part of the orbit, the floor of which is remarkably prolonged backwards and outwards; but the mutilation of the skull at this part has destroyed its true generic character. The pre-frontal bones are unusually developed, and descend lower than usual to form the anterior prominence of the orbits; the facial plates of the superior maxillary bones incline

inwards as they descend from the orbits: the lachrymal bones form the upper border of the nasal orifice, and the nasals, 15, and ascending intermaxillary bone, 19, form the anterior borders. The lateral branches of the intermaxillary bone form a thick convex inferior border bending in to the nasal aperture immediately above the alveolar edge: the facial plate of the superior maxillary, 20, slopes into the nasal cavity from behind. Although the present fragment, on which the *Dicynodon strigiceps* is founded, includes a smaller portion of the skull than that belonging to the *Dicynodon testudiceps*, the distinctive features of the species are more striking and more strongly marked: it ought perhaps to be referred, in the absence of decisive evidence of the maxillary tusks, to a distinct genus of Saurian reptile.

A nodule of the dark hard matrix displays a portion of the middle part of the skull of a small species or the young of a Dicynodon, with the inserted base of both tusks (Pl. VI. fig. 4.); these have the same circular transverse section, the same gentle curvature and oblique direction downwards and forwards as in the *Dicynodon lacerticeps*; but the facial part of the skull, anterior to the alveoli of the tusks, appears to have been relatively deeper and longer, and to have been characterized by a ridge extending longitudinally, midway between the nasal and alveolar borders: I shall not, however, at present dwell upon further differential characters, as these are susceptible of being more satisfactorily determined by the removal of some of the adherent matrix, for which operation there has not yet been time. Sufficient has been removed from the base of the fang of one of the tusks, *c*, to have exposed the germ of a successional tooth had such existed, but of this there is no trace. The fang of the tooth retains the same size and shape to the base, which is excavated by a moderately deep, conical pulp-cavity.

Dicynodon Bainii.

Two portions of the skull of a large *Dicynodon* exhibit each the base of a tusk, nearly two inches in diameter, the transverse section of which is subelliptical. A portion of the malo-maxillary bone with the beginning of the zygoma may be distinguished in one of these portions, but the specimens have been considerably crushed, distorted and fractured. The decomposition of the dentine of the tusk into concentric lamellæ is well-displayed in one of these specimens. The regular subelliptical form of the tusk has not been produced by compression, but is evidently natural to the species, and distinguishes it from the foregoing smaller specimens. I propose therefore to attach to this, the largest species of Dicynodon, the name of the discoverer, Mr. Bain.

Summary.

In reviewing the relations of the Dicynodonts to other Reptiles, recent and extinct, which have been elicited by the examinations and comparisons of the fossils described in the foregoing pages, the result may be generally summed up as proving the cranium, in this peculiar extinct genus or family, to have been organized according to a type essentially Lacertian, but with Crocodilian and Chelonian modifications, and with very peculiar dicynodontal characters engrafted on that composite basis.

The Crocodilian structure is chiefly manifested in the occipital region of the skull, and gives place to the Lacertian characters in the upper and fore-part; but in regard to these deviations it must be remembered, that the distinctive features of the Crocodilian type are most broadly manifested in the existing representatives of the order, and are modified and rendered less salient in the more numerous and varied extinct members. Thus in the *Teleosauri*, the partial bony roof of the temporal fossæ, formed by the union of the post-frontal and mastoid, loses its broad development, and is reduced to the form of a slender column, which with the intermediate cranium is proportionally longer than in the Gavials. This region of the skull is still longer in the *Pistosaurus*, in which the parietal is perforated as in the Dicynodon and many Lizards. The traces of the normal separate nasal apertures still exist in the *Teleosauri*, at the point of convergence of the pre-frontal, lachrymal and superior maxillary bones. In the *Plesiosaurus* the Lacertian character of the cranial bones, as a decussating columnar framework, is more extensively displayed, and the two distinct nostrils alone exist at the situation which I have termed 'normal' in reference to the great Saurian division of the Reptilian class, because of its prevalence in the majority of the existing members, forming the Lacertian group of Sauria, and also in the majority of the extinct members, which in other parts of their organization are more nearly allied to the modern *Loricata* or Crocodiles.

It is necessary to bear in mind this tendency to the amalgamation of Crocodilian and Lacertian characters in the older *Loricata*, in order to form a right estimate of the value of those correspondences with the cranial peculiarities of the existing Lacertians which have before been detailed.

Nevertheless, the characters of the occipital condyle, the position and division of the nostrils, and above all, the condition and form of the intermaxillary bone, justify the conclusion, that the general type of cranial organization manifested by modern Lizards was that on which the peculiar modifications of the Dicynodon have been superinduced. It is not, however, amongst the modern Lizards that we find the nearest approximation to the Dicynodon. For this we must go as far back into the period of Reptilian existence as the epoch of the new red sand-

stone, when the *Rhynchosaurus* manifested the Lacertian type of skull combined with edentulous jaws, which most probably were sheathed with horn. But the Lacertian type is more closely adhered to in the Rhynchosaur than in the Dicynodon: as, for example, in the backward production from the upper angle of the orbit of the column or arch of bone, formed by the post-frontal and mastoid running parallel with the true zygoma, which is continued from the lower border of the orbit, as in the skull of the *Rhynchocephalus* (Pl. VI. fig. 5.). For other instances of the Lacertian affinities of the Rhynchosaur, I must refer to the Memoir descriptive of that extinct genus*. It does not detract from the Lacertian character of the Rhynchosaur, that the slender curved and produced intermaxillary bones are double; for the median suture still remains in the analogously, but less extensively produced intermaxillaries of the *Rhynchocephalus* above cited. What concerns us most in the present inquiry is the anomalous edentulous sharp edge of the upper and lower jaws in the ancient Rhynchosaur, and the Chelonian form of the deep lower jaw, the same anomaly having been repeated in the extinct African Lizard of apparently as remote a period, with the superaddition of Mammalian canine tusks. For the rest, however, much difference of form is manifested in the two extinct genera. Whilst the Rhynchosaur has the double, narrow and elongated intermaxillaries of the existing *Rhynchocephalus*, the Dicynodon presents the more usual undivided condition of that bone in the existing Lacertians, but with a much greater proportional development.

It is interesting, however, to remark the same peculiar contraction of the cranial cavity, indicating an arrested development of brain in both genera of ancient Lacertia. In the Rhynchosaur the temporal muscles met, and caused the development of a median crest of bone along the whole of the parietal bone. Secondary varieties which diversify the modern Lizards were also manifested by the two most ancient forms of the order. The difference in the intermaxillary bone has been already noticed. So with respect to the parietal bone: in the Rhynchosaur it is imperforate, as in *Cyclodus* and *Gecko*; whilst in the Dicynodon it is perforated, as in *Varanus*. So likewise with respect to the mid-frontal bone: in the Rhynchosaur it is single, as in *Thorictes* and *Iguana*; whilst in the Dicynodon it is divided, as in *Lacerta* proper and *Varanus*: again, each post-frontal bone is divided by a suture in the Rhynchosaur, as in *Iguana*, but in the Dicynodon the post-frontal is undivided, as in most existing Lacertians. The facial part of the skull is as peculiarly compressed in the Rhynchosaur as it is expanded and abbreviated in the Dicynodons. The dental peculiarity of the African Saurian forms its chief distinction from the Rhynchosaurus, as from all other Sauria: but with the strange superaddition of its two canine tusks, we must bear in mind that the affinities

* Cambridge Philosophical Transactions, vol. vii. part iii. p. 355.

linking the Dicynodon to Crocodilians and Chelonians are much more strongly manifested than they are in the Rhynchosaurus.

Before concluding this summary, I cannot omit adverting to an analogy of structure which radiates from the Dicynodon in the direction of the Ophidian division of existing Reptiles, although it is unsupported by any other concordances of cranial or dental organization than those which I am about to cite. In the poisonous Serpents, the Rattle-snake, for example, the intermaxillary bone is single and edentulous; the maxillary bone supports a long, curved, pointed tooth, which, when advanced, descends outside the lower jaw. Apart from all the other peculiarities of the maxillary and dental systems of the Poison-snakes, they alone, of all existing Reptiles, repeat, in the above-cited structures, the characters of the Dicynodon. But, in addition to the two large maxillary teeth, the Rattle-snake has smaller teeth in rows upon the palatine, pterygoid and mandibular bones. To complete the resemblance between the tusks of the Dicynodon and the venom fangs of the Snake, you must deeply groove their fore-part, or bore a canal through their centre; you must remove those strong columns of bone which converge to abut against and strengthen the fixed socket of the tusk, and you must suspend the maxillary bone by a moveable pedicle to the pre-frontal and malar bones. Besides, the perforated tusk of the poisonous Serpent is always followed by one or more similar teeth, in various stages of growth, ready to supply its place, according to the general law of the maintenance in serviceable state of the dental armature of the jaws throughout the Reptilian class.

I have made various sections in fragmentary specimens, and have closely inspected every example of the Dicynodon where the alveoli of the tusks were exposed, in quest of the germs of successional teeth or tusks of reserve, but without success. From the youngest specimen with tusks of two lines diameter, to the largest with tusks of two inches diameter, in which their inserted part is exposed to the base, they alike exhibit a conical excavation of that base* for the lodgement of a persistent matrix, and are solid in the remainder of their extent. In consequence of the peculiarly complex structure discovered in the tusks and teeth of the Labyrinthodonts of the new red sandstone, I was very desirous, from the commencement of the present investigation, to submit the tissue of the great canines of the Dicynodons to microscopic examination, and, with the sanction of the President, I have had the requisite longitudinal and transverse sections prepared from fragmentary portions of skulls containing portions of these teeth.

They offer no trace of the inflected labyrinthic folds of the capsule to which the characteristic ichthyic interblending of the cement and dentine in the teeth of the great Keuper Batrachian is due, but the microscopic specimens give additional evidence

* Pl. V. fig. 3, *d*.

of the true Saurian character of the Dicynodonts, by the close resemblance which they offer to the structure of the teeth of the Crocodile, Teleosaur and Plesiosaur.

The canine tusk of the Dicynodon consists of a simple body of compact unvascular dentine, with a very thin outer coat of enamel, which may be traced into the alveolus for a short distance. Rather more than one-third of the tusk is lodged in the socket, the basal conical pulp-cavity is continued from the base about one-half down the implanted part of the tusk, and a linear continuation extends along the centre of the rest of the tusk. From this central line the dentinal tubes of the solid body of the tusk radiate; with a gentle curve at their beginning, convex towards the point of the tusk, and then proceeding straight to the periphery of the tooth; not quite vertically to that surface, but slightly inclined downwards, or towards the apex. They present gentle parallel secondary curves or undulations throughout their course, divide dichotomously twice or thrice near their beginnings, and send off numerous small lateral branches, chiefly, but not exclusively, from the side next the apex. At their primary curve, near the centre of the tooth, the dentinal tubes measure $\frac{1}{12000}$th of an inch in diameter, and are separated by intervals of double that breadth, or $\frac{1}{6000}$th of an inch. They diminish in size as they approach the periphery of the dentine and terminate close to the enamel by dividing or breaking up into minute irregular ramuli. The dentinal cells are most conspicuous, as in the teeth of the Crocodile*, near the periphery of the tooth; they are subhexagonal, and vary in diameter from $\frac{1}{800}$th to a $\frac{1}{1000}$th of an inch†. The stratified arrangement of these cells in planes parallel with the surface of the tooth is very conspicuous, as in fossil teeth generally, from the partial decomposition of the basal tissue of the dentine. To the naked eye, or with a low power, this disposition of the dentinal cells gives the appearance of a concentrically-laminated structure of the dentine; the more highly organized and characteristic tubular structure demanding higher powers for its detection. The enamel, at least at the middle of the tusk, where I have examined it, is thinner than in the teeth of the Crocodile; it presents only a finely lamellated texture, the layers being parallel with the surface of the dentine on which it rests. There is only a fine linear trace of cement on the exterior of the sections of the implanted base of the tusks; and here it is too thin to allow of the development of the radiated cells in its substance.

The principal difference in the microscopic texture of the tusks of the Dicynodon. as compared with the teeth of the Crocodile, consists in the closer and more com-

* See Report of British Association, 1838, p. 144.

† The observations on the dental tissues of the Dicynodon were made both with my own (Smith's) microscope and with the splendid instrument with screw-micrometer (Powell's), in the possession of my friend C. Stokes, Esq., for whose kind aid in these and similar microscopic inquiries I beg to express my grateful acknowledgements.

pact arrangement of the calcigerous tubes of the dentine; by which character it makes a closer approach to the intimate texture of that tissue in the canine teeth of the carnivorous Mammalia. I have shown, however, in my 'Odontography*,' that the teeth of the Crocodilian Reptiles which are implanted in sockets have the same essential type of structure as the simple teeth of the carnivorous Mammals. The difference consists of slight and secondary modifications of the minute tubular structure, and these disappear in the very remarkable teeth of the ancient extinct Sauria under consideration.

In the other Reptilia, recent or extinct, which most nearly approach the Mammalia in the structure of their teeth, the difference characteristic of the inferior and cold-blooded class is manifested in the shape, and in the system of shedding and succession, of the teeth: the base of the implanted teeth seldom becomes consolidated, never contracted to a point, as in the fangs of the simple teeth of Mammalia, and at all periods of growth, one or more germs of teeth are formed within or near the base of the tooth in use, prepared to succeed it, and progressing towards its displacement. The dental armature of the jaws is kept in serviceable order by uninterrupted change and succession; but the matrix of the individual tooth is soon exhausted, and the life of the tooth itself may be said to be comparatively short.

Hitherto I have not failed to obtain evidence of this low organized dental condition,—common to Fishes†,—in every Reptile, recent and extinct, in which I could examine the implanted base of the teeth.

The existing Lacertians superadd to this endless shedding and succession of teeth, the ichthyic character of anchylosis of the base of the teeth in use to the osseous substance of the jaw; so that in the *Rhynchocephalus* and other Acrodont Lizards‡, the teeth appear like small enamelled processes of the alveolar border. The Dicynodons not only manifest the higher type of free implantation of the base of the tooth in a deep and complete socket, common to Crocodilians, Megalosaurs and Thecodonts, but make an additional and much more important step towards the Mammalian type of dentition by maintaining the serviceable state of the tusk by virtue of constant renovation of the substance of one and the same matrix, according to the principle manifested in the long-lived and ever-growing tusks and scalpriform incisors of the Mammalia. This endowment of the teeth of a Reptile is far more remarkable and unexpected than the more obvious character of the size and shape of the long exserted tusks themselves, superadded as they are, and in such strange combination, with the otherwise edentulous jaws of a

* Part II. pp. 281, 291.

† Anomalous rostral teeth of *Pristis* and compound dental masses of *Chimæroids* excepted.

‡ Odontography, p. 182.

Bird or Turtle. Yet if we consider the fact teleologically, or in its relations to the exigences and convenience of the living animal, the wisdom and beneficence of the principle is apparent, and the departure from the ordinary rule manifests a power transcending the trammels of scientific system. The teeth of the Dicynodon being but two in number, and their use to the animal indicated by their unusual size to be of unusual importance, the inconvenience and detriment that must have ensued from frequent shedding and replacement is very obvious; we may readily conceive it to have been incompatible with their functions, and therefore abrogated in favour of another mode of renovation which is abnormal in Reptiles, simply, perhaps, because the form, proportions and function of such tusks were unique, and are now no longer manifested in a cold-blooded class.

Some observations may be naturally expected in reference to the probable use of the tusks to the Dicynodons, and the mode of life of those ancient and most remarkable Saurians. In the Mammalian class, where alone we now find the analogous instruments, tusks are usually given as weapons of offence and defence, —an office exemplified in the hornless Musk-deer, the Boar, and in the large canine teeth of the Carnivora. The Elephants use their tusks chiefly, though not exclusively, as lethal weapons: the Walrus is said to apply his tusks to aid in clambering over icebergs, as well as in combat and defence: the Dugong is supposed to wear the exserted points of the tusks in detaching fuci for food. Such an office at first suggests itself as a very probable one in regard to tusks descending, like those of the Dugong, from the upper jaw, and combined with edentulous and probably horny mandibles like those of a fucivorous Turtle.

On inspecting the remains and the impressions of the tusks in the fossils under consideration, and especially in the almost entire skull of the *Dicynodon lacerticeps*, we perceive that these weapons are sharp-pointed, and present no trace of that obliquely beveled or chisel-shaped extremity which is produced by habitual application in acts of obtaining daily food, as, for example, in the protruded extremities of the tusks of the Dugong and the incisors of the Rodents. The tusks of the Dicynodon, though similar, in their origin from maxillary bones and downward direction, to the tusks of the Walrus, are so much shorter, at least in the single specimen in which their entire length is shown, that they could not be available in locomotion. I conclude therefore from their shape, proportional length, sharp points and dense texture, that the tusks of the Dicynodon were applied by the living animal either for the purpose of killing its prey, or of defending itself from its foes, or in both acts; and that they were offensive and defensive arms.

A further insight into the habits and mode of life of the Dicynodons may reasonably be expected to follow the examination of the skeleton of the trunk and the organs of locomotion. This will form the subject of a subsequent memoir; but I

may here state, that the vertebræ of the Dicynodon present the sub-biconcave structure common to most of the older extinct Saurians, which structure, in comparison with the ball and socket vertebræ of the modern species, indicates a more aquatic and perhaps marine theatre of life for the Amphibia that swarmed in such plenitude of development and diversity of forms during the ancient secondary periods of the geological history of this planet.

DESCRIPTION OF THE PLATES.

Plate III. *Dicynodon lacerticeps.*

Fig. 1. Side view of the skull.
2. Upper view of the skull.

Plate IV.

Fig. 1. Front view of the skull.
2. Back view of the skull (occiput).
3. Upper view of the fore-part of the lower jaw.
4. Under view of the skull.
5. Section of lower jaw one-third from the condyle.
6. Section of the same jaw one-third from the symphysis.

Plate V. *Dicynodon testudiceps.*

Fig. 1. Under view of anterior two-thirds of the skull, showing the bony palate.
2. Upper view of the same portion of skull.
3. Longitudinal section of the root or implanted part of the tusk.
4. Transverse section of the base of the tusk.

Plate VI.

Fig. 1. Side view of anterior two-thirds of the skull of *Dicynodon testudiceps*.
2. Side view of anterior half of the skull of *Dicynodon strigiceps*.
3. Under view of the same portion of skull.
4. Portion of maxillary bone, with the root of the tusk and basal pulp-cavity exposed, of a young *Dicynodon*.
5. Side view of the skull of an Acrodont Lizard, indicating a nondescript genus (*Rhynchocephalus*) by the division of the intermaxillary into two bones, as in the extinct *Rhynchosaurus*.
6. Under view of the same skull.
7. Upper view of the same skull.

The following figures and letters indicate the same parts in each Plate.

1. Basi-occipital: 1′, inferior processes of ditto.
2. Ex-occipital: 2′, outer process of ditto; 2″, condyloid foramen.
3. Par-occipital process, abutting against tympanic pedicle.
4. Sur-occipital.
5. Basi-sphenoid.
7. Mastoid.
8. Parietal. It is perforated in *Dicynodon*, as in *Rhynchocephalus*, *Iguana*, and many other recent Lacertians.
11. Post-frontal.
12. Mid-frontal.
13. Vomer. It sends down a strong median longitudinal ridge in *Dicynodon*.
14. Pre-frontal.
15. Nasal.
16. Lachrymal.
19. Intermaxillary: 19′, palatine ridges of ditto.
20. Maxillary.

20 *a*. Malar.

21. Palatine.
24. Dentary piece of mandible or lower jaw.
25. Articular piece.

25 *a*. Splenial piece.

26. Angular piece.

26 *a*. Coronal piece.

27. Zygomatic or temporal.
28. Tympanic.

c. Canine or maxillary tusk.

d. Cavity for dental pulp.

m. Foramen magnum.

n. Nasal apertures.

o. Orbits.

p. Palatine or posterior nasal aperture.

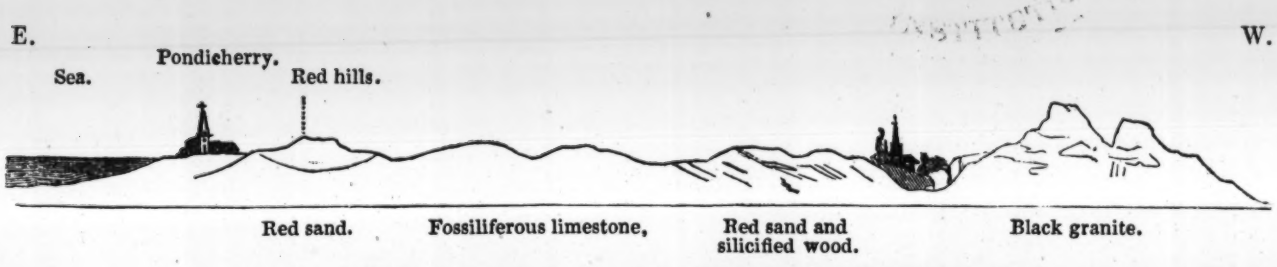
t. Vacuities for the temporal muscles: in Pl. V. fig. 2. it marks part of the surface whence the muscles took their origin.

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IV.—*Observations on certain Fossiliferous Beds in Southern India.*

By C. T. KAYE, Esq., F.G.S., *of the Madras Civil Service.*

[Read June 29th, 1842.]



SKETCH OF THE COUNTRY NEAR PONDICHERRY.

THE fossiliferous beds which form the subject of the following paper occupy positions at some distance from each other. The first and most interesting of them is situated in the neighbourhood of Pondicherry. The silicified wood, found in the adjacent sandstones, has long been known to the inhabitants of that part of the country, from the fine polish which it admits of and its capability of being formed into ornaments; but the beds of limestone which have furnished the material for the pavement for the streets of Pondicherry, and which lie within seven miles of the French capital in India, have almost entirely escaped observation.

Pondicherry itself, as well as Madras, is situated on a very recent formation of loose sand, which extends for a considerable distance along the eastern coast of India, and which in many cases contains marine shells in such abundance that they are dug up and burnt for lime. I have obtained specimens from a spot about thirty miles from Pondicherry and ten from the coast. They are all shells such as now inhabit the Indian seas, and consist of—1. *Pyrula vespertilio*; 2. *Purpura carinifera*; 3. *Cardita antiquata*; 4. *Pullastra*; 5. an undescribed species of *Cytherea*; 6. *Arca granosa*; 7. *Arca rhombea*. This formation is usually bounded by granite, which comes to the surface at Sadras, Madras, and many other places along the coast. Immediately behind the town of Pondicherry, however, the recent beds rest upon some low hills of red sandstone, which encloses an abundance of quartz pebbles, and occasionally passes into conglomerate, but contains no fossils. Passing these small hills, you come upon the bed of limestone which contains the greater part of the fossils now before the Meeting. At a distance of about four miles due

west, you again come upon red sand with quartz pebbles, which here contains a vast quantity of silicified wood; and, at a distance of about sixteen miles from the sea, this is again bounded by hills of black granite.

It is much to be regretted that the generally undulating surface of the country nowhere affords anything like a section: it is still therefore a desideratum to ascertain the relative position of the limestone and sandstone; though a variety of circumstances lead to the inference, that the limestone is the more recent of the two*. The annexed diagram illustrates the general character of the surface of the country.

Observing that the pavement of the streets of Pondicherry and the steps of many of the houses were replete with marine shells in a very good state of preservation, I was induced, towards the close of 1840 (although totally unused to geological investigation), to visit the quarries from which the stone was obtained. I found them very near the surface, and not exhibiting any section of the strata; but this visit put me in possession of several characteristic fossils, and led me to repeat the visit at subsequent opportunities; so that, in the course of the following year, I was enabled to make a very complete collection of the organic remains of the Pondicherry limestone.

The limestone which contains these fossils does not occupy an area of more than three or four square miles. It forms an undulating plain, and is bounded, both on the east and on the west, by a formation of red sandstone. The country rises gradually towards the west, and it is in this direction that the petrified trees, already alluded to, are found in great numbers. The wood, found in the limestone, is always converted into a calcareous substance; but these trees are silicified; and while the former has in every instance been pierced by the Teredo, and bears other marks of having long been the sport of the waves, the silicified wood is never touched by the worm, nor do the trees bear any other sign of having been water-worn, than that they are always denuded of their branches and roots. Some of these trees are of vast size; one of them we traced, partly buried in the red sand, to the length of nearly 100 feet. Those which are more completely cleared of the soil bear a perfect resemblance to recent trunks of fallen trees, and are in every respect more perfect and more interesting than the celebrated petrified forest of Cairo, which I have since visited. They are all of them apparently of the same description; they are coniferous trees, and being grouped together within the space of a few miles, and bearing no appearance of having been long subjected to the action of water, they cannot have been removed to any distance from the spot where

* In a more recent account of these beds by Captain Newbold the sandstone is described as "lateritic grit," and therefore much newer than the limestone. See Journal of Asiatic Society, vol. viii. pp. 214, 240. ED.

they originally grew. They must also have constituted a very different order of vegetation from that which now flourishes on the eastern coast of India. The most common tree now growing in the neighbourhood of these ancient woods is the Tamarind, and from this circumstance and some fancied resemblance in the colouring of the stone, the petrified trees are generally known both to the European and native inhabitants of that part of the coast by the name of Tamarind wood: but their vast straight stems bear no resemblance whatever to that tree, and it is easy to suppose that they must have belonged to some gigantic member of the Pine tribe.

The fossiliferous beds to which I would next call attention are situated in the district of Trichinopoly, and about thirty miles from that town. They are about 100 miles from Pondicherry and sixty miles from the sea: as I have never been able to visit this spot, I regret that I am unable to give any accurate description of these beds; but I am told that, like the deposit in the neighbourhood of Pondicherry, the Trichinopoly limestone occupies but a small area. I have, however, had several cart-loads of the rock forwarded to me, and believe that I am thus enabled to lay before the Society a complete series of the fossils which it contains. It is a fine dark limestone; and the shells, which are exceedingly numerous, stand out in relief on a weathered surface of the stone, and being perfectly white, they contrast beautifully with the black matrix; but when the stone is fresh broken, the shells not unfrequently retain much of their original colour, and, generally, all their pearly lustre.

There is still another deposit of fossiliferous limestone to which I beg now to direct attention, forming perhaps a link between the two limestones already noticed. It is situated in the district of Verdachellum in Southern Arcot, about forty miles from the coast and fifty from Pondicherry. Lieut. Newbold, of the Madras Army, remarked, in one of the Madras 'Journals of Literature and Science,' that he thought it highly probable that the fossiliferous limestone of Pondicherry extended into the Verdachellum district. It was owing to this suggestion of Lieut. Newbold that I was induced to make inquiries in that direction. The natives of the country are so little observant of circumstances of this sort, that it was long before I was enabled to obtain any information respecting it. A gentleman resident there forwarded to me, however, a short time before I left India, specimens of a limestone which he had accidentally discovered, containing Pectens, and a few fragments of other shells, which were sufficient to induce me, as soon as possible, to visit that part of the country. Verdachellum is situated on a formation of red sand, containing rounded quartz-pebbles, occasionally passing into conglomerate, precisely resembling the red sand formations near Pondicherry. It contains no marine fossils, but I have obtained one specimen of silicified wood. About six

miles from Verdachellum, the valley of the river is formed of an impure limestone, which underlies the red sand and contains marine fossils. It contains no Baculites or Hamites; but there are several varieties of Ammonite, differing from those found near Pondicherry; and some of these must have attained a very great size. There is also a Nautilus and a Spatangus, both distinct from those found at Pondicherry.

I will offer only a few general remarks with regard to these deposits. The prevalence of the Baculite, Hamite, Ammonite and Belemnite in the Pondicherry limestone seems clearly to indicate that this formation belongs to the secondary æra, and especially points to the period of the cretaceous beds as the equivalent among European formations. There is among these fossils a single vertebra of a Saurian, which in Professor Owen's opinion most nearly resembles that of *Mosasaurus*. On the other hand, the prevalence of Volutes (of which there are eight species) and the presence of Pyrula, Cypræa, Cerithium and Scalaria, would lead to the conclusion that the period to which they belong is tertiary, and at any rate appear to indicate an unusual mixture of forms. The notion of there being this mixture receives support from a review of the fossils of the other deposits I have mentioned; for it will be observed that such shells from the Trichinopoly limestone as can be identified with known species, are all tertiary shells of the Paris and London basins, and that most of the others very nearly resemble tertiary shells. One of the Volutes has been decided by Mr. Sowerby to be common to Trichinopoly and Pondicherry: and I obtained, with the tertiary shells from Trichinopoly, a large cast of the chamber of an Ammonite; and, lastly, several of the shells which at Trichinopoly are associated with tertiary forms, are again found at Verdachellum associated with Ammonites and Pectens*.

* See the conclusions arrived at by Professor E. Forbes as expressed in the annexed Report on these shells, in which these identifications are disputed.

APPENDIX.

On the Remains of Fishes found by Mr. Kaye and Mr. Cunliffe in the Pondicherry Beds.

By Sir PHILIP GREY EGERTON, M.P., F.R.S., F.G.S.

[Reprinted from the Quarterly Journal of the Geological Society, vol. i. p. 164.]

THE fish remains collected by Mr. Kaye and Mr. Cunliffe in the neighbourhood of Pondicherry having been placed in my hands for examination, I have endeavoured to discharge the task committed to me to the best of my ability, by comparing the Indian fossils with analogous forms from other localities, and with the figures and descriptions given by Agassiz in the 'Poissons Fossiles.' The collection consists wholly of teeth; they are, generally speaking, in bad condition, few of the Placoid teeth retaining their bases, a very essential element in the identification and description of species. Before proceeding to detail the characters of the several specimens, it may be advisable briefly to relate the results at which I have arrived from the study of these ichthyolites. With the exception of two specimens, the collection is entirely composed of teeth of Squaloid fishes. Of these two exceptions one belongs to the Ganoid order and to the family of *Pycnodonts*, and it is probably a *Sphærodus*; the order is referred to the Cycloid genus *Enchodus*, the teeth very closely resembling those of *Enchodus halocyon*, a species common to the chalk of England, continental Europe, and North America. Of the Placoid remains, two species only belong to the section of the Squaloid family with serrated teeth, and both of them are referable to the genus *Corax*, which Agassiz informs us is restricted to the chalk. One species is not distinguishable from *Corax pristodontus* of the Maestricht beds. The other is undescribed. The Squaloid teeth with cutting edges compose the bulk of the collection. They are referable to at least a dozen species, all corresponding in the absence of plaits or striæ on the surfaces of the enamel. Although there are close approximations amongst them to the species both of the Cretaceous and Miocene period, yet it is somewhat remarkable that I have not seen a feature nor a character which recals in the remotest degree the forms of the Eocene period. They belong principally to the *Odontaspid* type; one species being closely allied to, if not identical with, the *Odontaspis rhaphiodon* of the chalk of Europe. Two or three species are referable to the genus *Otodus*, one approaching *Otodus appendiculatus*; also from the chalk. Of the genera found in the Pondicherry beds, the following is the stratigraphical distribution assigned by Agassiz. The genera *Lamna*, *Odontaspis*, and *Oxyrhina* extend from the recent

period to the Greensand inclusive, the Jurassic species being now separated from Lamna under the generic title of *Sphenodus*, and from Oxyrhina under that of *Meristodon*. Otodus extends from the Crag to the Greensand, and Corax is restricted to the true chalk. The Ganoid genus *Sphærodus* ranges from the Tertiary beds to the Oolite, and the Cycloid *Enchodus* is restricted to the chalk. The distribution of species is as follows:—*Lamna*, 5 tertiary and 1 cretaceous; *Odontaspis*, 5 tertiary, 4 cretaceous; *Oxyrhina*, 11 tertiary, 2 cretaceous; *Otodus*, 8 tertiary and 5 cretaceous; and *Corax*, 5 cretaceous. Of the five Placoid genera we have twenty-nine species occurring in the Supercretaceous, and seventeen in the Cretaceous deposits; but not a single species has yet been found anterior to the latter period. The evidence, then, afforded by the Pondicherry fishes appears to yield strong corroborative testimony to the accuracy of Mr. Forbes's views, derived from the study of the invertebrate remains of the same locality; and I fully coincide with him in assigning these strata to the Cretaceous period. I am however inclined, considering the number of species collected which must be referred to genera which we know decrease in species as they descend in the stratigraphical scale, from the occurrence also of Maestricht species, and from the presence of the genera *Corax* and *Enchodus* not yet found so low as the Neocomian, to place this deposit higher in the system than Mr. Forbes is inclined to do from his investigations. As I have above stated, the Placoid teeth are for the most part mutilated, rendering the generic identification a matter of much difficulty and uncertainty, although the specific characters are good and distinct. Agassiz says*, "It frequently happens that the root and the lateral cusps are detached from the dental cone, and in this case it is very difficult to distinguish Otodus from Oxyrhina. I shall describe hereafter several species very well characterized, but of which the genus is doubtful, because the perfect root is not known." Again, in prefacing the genus Oxyrhina, he says, "When the base of the root is mutilated, it sometimes happens that one is in doubt whether the species belongs to the genus Oxyrhina, Lamna, or Otodus." He also remarks, after comparing the genus Lamna with Oxyrhina, "The steps from Otodus to Lamna are more gradual, and here we find some species which are actually on the limits between the two genera." Some of the Indian species are in this category, for we find the principal dental cone of the form and aspect of an Otodus associated with the long pointed cylindrical lateral cusps of an Odontaspis, and the flattened cultriform tooth of an Oxyrhina furnished with smooth lateral cusps which exclude it from that genus. It is with much hesitation that I have ventured to draw up the following descriptions of the more perfect specimens of the Pondicherry collections, from a consciousness of my own inability to grapple with this most difficult branch of fossil ichthyology, not

* Poissons Fossiles, vol. iii. p. 266.

unmixed with doubts of the stability of the generic and specific characters as at present acknowledged in the 'Poissons Fossiles.' Agassiz has himself complained of the paucity of materials for arriving at any very definite conclusions as to the variations of form in the teeth occurring in the various positions in the mouth of the same species. Those naturalists who have studied the recent Sharks are well aware of the extent of those variations in a single individual, and can, therefore, appreciate the difficulties under which Agassiz has laboured in attempting a systematic arrangement of the fossil Squaloids. As I am in hopes this distinguished ichthyologist will shortly have an opportunity of examining the Indian collections, I offer the following descriptions as provisional rather than final; or, at all events, as giving the characters of forms in themselves distinct, but which may hereafter be grouped together under legitimate generic and specific denominations.

Cycloid Order.

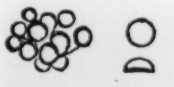
Scomberoid Family.

Enchodus serratus, Eg.—Three teeth from the Pondicherry beds evidently belonging to the genus *Enchodus*. As I have before stated, they bear a very close resemblance to the species figured by Agassiz as *Enchodus halocyon*; at the same time (although the materials are too defective to warrant any definite conclusion), there are appreciable discrepancies of sufficient importance to induce me to abstain from identifying the Indian teeth with the species alluded to. The most perfect specimen, as compared with teeth of similar size of *E. halocyon*, presents the following distinctive characters. The surface of the enamel is more smooth and even, in consequence of the fineness of the longitudinal striæ, which in *E. halocyon* are coarse and strongly marked. The transverse bands are broader, and the form of the teeth is less attenuated. The most important feature it presents is in the finely serrate cutting edge, which in all the specimens I have seen of *E. halocyon* is smooth and entire. A second fragment corresponds in all these points. The third specimen is a smaller tooth, and only differs from *E. halocyon* in the smooth and highly polished surface of the enamel. None of these teeth are perfect. The length of the largest is half an inch, of the smallest two lines.

Ganoid Order.

Pycnodont Family.

Sphærodus rugulosus, Eg.—All the tritoral teeth in the Indian collections appear to belong to one species of the genus Sphærodus. A pretty group in Mr. Kaye's series shows nine teeth *in situ* of those in use, and underneath there are the germs of several of their successors. Three detached teeth appear to have belonged to the same specimen. In Mr. Cunliffe's collection I have found two tritores, considerably larger than the specimens alluded to above, but evidently belonging to the same species. In size these teeth resemble those of *Sphærodus lens*, the smallest species figured by Agassiz; in regularity of form they approach nearer to *Sphærodus parvus*; but they are distinguished from these species and all others figured by Agassiz by the wrinkled or shrivelled appearance of the superficies of the teeth. This is visible even in the smallest specimens, and forms a well-marked and easily appreciable specific character.



Placoid Order.

Squaloid Family.

Corax pristodontus, Agass. Poiss. Foss. vol. iii. p. 224.—A single fragment is the only evidence upon which rests the supposition that this species enjoyed the extended geographical range indicated by its occurrence in the Cretaceous system of Europe and India. This specimen shows the outer surface of the hinder portion of a sinistral tooth. The base is wanting. It corresponds in minutest detail with the analogous portions of a tooth received from Professor Goldfuss, named by Agassiz *Galeus* (now *Corax*) *pristodontus*, apparently from the Maestricht beds. A comparison with the figures given in the 'Poissons Fossiles' yields a like result. Some specimens in Mr. Lyell's cabinet, from the chalk of North America, approximate very closely to this species. Should they be identical, it will prove this to be one of the most widely distributed fossil forms of fishes with which we are acquainted.



Corax incisus, Eg.—A second species of Corax occurs in the Indian collection sent over by Mr. Cunliffe, of small size and very distinct character. It is rather smaller than the species of this genus generally are, corresponding in this respect with *Corax planus*, of which some imperfect specimens are figured in the 'Poissons Fossiles' from an unknown locality. Our specimens are not perfect, but they are sufficiently so to prove them to be specifically distinct from

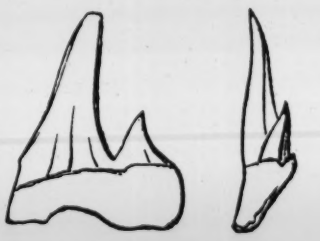


all those figured and described by Agassiz. The principal cusp is conical, rather slender, and pointed. It is more upright and less falcate than usual. The antero-posterior diameter of the tooth is small, in this respect resembling *Corax planus*. The character of the marginal armature is peculiar. It is rather notched or crenulated than serrate, the subdivisions of the edge being blunt and irregular. The lateral cusp is smooth, and corresponds with its principal in the character of its dentelures.

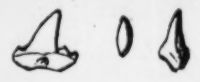
Otodus? marginatus, Eg.—Several of the Indian Squaloids are apparently referable to the genus *Otodus*. Of these, two have some resemblance to the common *Otodus appendiculatus* of the chalk formation; and although the characters of this species, as at present recognised, are wide enough to embrace an extensive variety of forms, yet they are sufficiently defined to exclude the Indian specimens. The larger species, of which I have found four specimens, is remarkable for the rapid increase of the antero-posterior diameter of the shaft as it approaches the base. The latter is thick and massive, with a deep depression on the outer surface. The cone in profile is regularly and distinctly incurved from the apex to the junction with the base. It is narrower than in most specimens of *O. appendiculatus*. The outer surface is smooth and rounded; the inner one is also smooth, and more arched than in any species I am acquainted with. A section, taken one-third distant from the base, would represent the inner face of the tooth as nearly semicircular. The cutting edge is sharp, and so distinct as to have the appearance of a border, separated from the remainder of the shaft by a shallow groove. The lateral cusp is large, conical, and sharp, having more resemblance in these respects to this feature in the Odontaspid teeth. The corresponding cusp is broken; but the fracture shows that, in all probability, the tooth was symmetrical.



Otodus basalis, Eg.—A tooth sent to England by Mr. Cunliffe has a closer resemblance to *O. appendiculatus* than the species last described. Of the various forms comprehended in this species, one fossil most nearly approximates a tooth from the Maestricht quarries. Its peculiar distinctive features are, the larger size of the lateral cusp, the greater breadth and obliquity of the base, and the smaller proportions of the principal cone compared with the other dimensions of the tooth. When viewed in profile, the principal cone is straight and narrow, and the cusp from its inward slope forms an acute angle with the principal cone. Both surfaces are smooth and rounded; the inner are, as usual, rather more so than the outer. The tooth is slightly oblique, but not so much so as the Maestricht specimen. As this feature varies according to the position of the tooth on the jaw, it is of little value.



Otodus nanus, Eg.—A single tooth in Mr. Kaye's collection, referable to the genus Otodus, differs from the other species of the same genus in its diminutive size. The central cusp is triangular, equalling in height the breadth of the base. It has a thick and stunted aspect, being equally convex on either surface. It is incurved, and slightly obtuse at the apex. The lateral cusps are short, wide, and blunted.



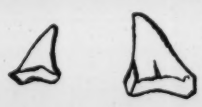
Otodus divergens, Eg.—An unique specimen in Mr. Cunliffe's collection, although differing in some respects from the general characters of the genus Otodus, has notwithstanding more resemblance to this than to the Squaloids of any other genus. The central cusp, from its sharp, flattened, and lanceolate form, resembles an Oxyrhina or Lamna; but the large development of the lateral cusps must exclude it from those genera. From Odontaspis it differs in the width and general character of the lateral cusps. The latter are exact miniature representations of the principal cusp, and are so placed upon the base as to slope outwards on either side. They have each a small supernumerary point on the outer shoulder. The tooth is slightly convex on both sides; the point is somewhat recurved; and the edges of all the cusps are remarkably sharp. This is a perfect and very interesting specimen.



Otodus minutus, Eg.—The last specimen I refer to this genus is of small size, not exceeding the dimensions of *Otodus nanus* described above, yet of different form. The principal cusp is more lanceolate, and the antero-posterior diameter is infinitely smaller, compared with the height of the tooth. The profile is straight, not incurved as in *O. nanus*. The lateral cusp is small and blunt. A prominent ridge borders the enamel at its junction with the base.



Oxyrhina triangularis, Eg.—It requires specimens of unusual perfectness to enable the palæontologist to discriminate between the species of the genera *Oxyrhina*, *Lamna*, and *Otodus*. The Indian teeth, being for the most part imperfect, it is a matter of great difficulty and uncertainty to decide to which genus many of them belong. The proposed arrangement of species must, therefore, be considered as a mere approximation, or rather, perhaps, as provisional, until more perfect specimens, or one more skilled in Fossil Ichthyology, shall clear up the obscurity. Several smooth teeth in the Indian collections are remarkable for their regular triangular form. They appear to have been destitute of lateral appendages. The base in this species is broad, equalling the total height of the tooth. The cone is flattened on the outer surface and rounded on the inner. The enamel of the latter descends lower on the base at the sides than at the centre: the line of boundary thus represents an ascending obtuse angle. The teeth are more or less oblique according to the position they hold on the jaw. It is one of the smallest species of the genus.



Lamna complanata, Eg.—The occurrence of a small lateral cusp in some of the specimens of this species marks it as belonging to the genus *Lamna*, although in other respects it would more properly be considered as an Oxyrhina. Its nearest analogies are with *Oxyrhina xiphodon* and *hastalis*. It differs from the former in having the outer surface more prominent, and the inner one more evenly rounded without the flattened character of the basal portion of the enamel. From the latter it differs in the less prominent contour of the inner surface. It is distinguished from both by the presence of the lateral cusp, in being infinitely smaller, and in its slender and elegant proportions. The transverse section shows the antero-posterior diameter to be exceedingly narrow—more so, indeed, than in any other species of the genus.



Lamna sigmoides.—It is difficult in a mere verbal description to make intelligible the minute distinctions which, in considering the characters of the fossil Squaloid teeth, are the elements on which the species are eliminated. A single tooth sent home by Mr. Cunliffe recals at first sight the well-known *Lamna acuminata* of the British chalk. It approaches also that species in size, being one of the largest of the Indian specimens, which, generally speaking, are of unusually small dimensions. In form it is intermediate between *L. acuminata* and *L. cuspidata*. It differs, however, from both in the sigmoid flexure of the cutting edge. There are no lateral cusps visible. In front it varies from the form of *L. cuspidata* in the greater breadth of the apex, and from *L. acuminata* in the parallelism of the sides in the middle region of the tooth. The outer surface is flattened until near the point, where it is slightly rounded. The inner surface is convex and prominent. Seen in profile, the cutting edge conceals the back of the tooth for two-thirds of its length; it then verges inwards until near the point where it again tends slightly outwards. The base is partially concealed by the matrix; but it appears to have been furcate, and of rather small size.



Odontaspis constrictus, Eg.—A very large proportion of the Indian Odontolites belong to the species now under consideration. Out of some dozen of specimens, I have not, however, found one having the base sufficiently perfect to show whether it supported lateral cusps or not. If they were present, they must have been of very small size. Under this uncertainty it is impossible to determine whether this species should be placed under the genus Lamna or Odontaspis; but I am inclined, from the slender subulate aspect of the teeth, to refer it to the latter. At the time of writing this, I have not been able to compare the Indian specimens with figures of *O. gracilis* from the chalk and *O. subulata* from the lower greensand of Neufchâtel; but the descriptions given of these species lead me to infer a considerable resemblance



in size and form with the Indian species, although the latter has a very distinctive feature in the cessation of the cutting edges before they reach the base, giving a constricted appearance to the shaft of the tooth. This character is well-marked in *Odontaspis contortidens* of the Molasse ; indeed our Pondicherry fossils are only distinguishable from this species by the absence of the striæ on the inner surface of the teeth.

Odontaspis oxyprion, Eg.—The last species I propose to describe in this memoir is also frequent in the Indian collections. It belongs without doubt to the genus *Odontaspis*, and is very nearly allied to *O. rhaphiodon*. The comparison, however, is less accurate than I could wish, owing to my not being able to refer to Agassiz's plate on the subject; but one character establishes at once the distinctness of the Indian species, viz. the absence of striæ on the inner surface of the tooth. Some of the specimens of this species are in a good state of preservation, showing the form of the base and the lateral cusps. It is not impossible that more than one species may be included in this description, as some of the specimens are more convex than others on the outer surface, and less recurved at the point. The number and form of the lateral cusps also vary considerably; but there is a general resemblance which induces me for the present to include all under one denomination. In the form of the central cone they agree very closely with *Odontaspis rhaphiodon*; but the lateral cusps are larger, more elongated, and sharper at the points, and in these respects they exceed even the recent *Odontaspis ferox*. They are sometimes single, sometimes double, on each side, and occasionally single on one side and double on the other. The base is broader and less deeply notched than in *O. rhaphiodon*.



A considerable number of specimens remain to be examined; but most of them will probably belong to one or other of the species described above. Should any distinct forms be found, they will be treated of in a future memoir.

V.—*Report on the Fossil Invertebrata from Southern India, collected by Mr. Kaye and Mr. Cunliffe.*

By EDWARD FORBES, F.R.S., F.G.S. &c., *Professor of Botany at King's College, London; Palæontologist to the Geological Survey of the United Kingdom.*

Part the First.—*Description of the Species.*

Mollusca.

Cephalopoda.

Genus Nautilus, Linnæus.

THERE are four well-marked species of this genus in the collection. Two of them appear to be identical with European species, and two are new. The former are cretaceous forms: of the latter, one is nearly allied to a cretaceous and the other to oolitic species. Not one of the specimens is in perfectly good condition, so that the certainty of the determinations may hereafter be questioned.

1. *Nautilus lævigatus*, D'Orbigny?

N. testâ subglobosâ, inflatâ, lævigatâ, subumbilicatâ; aperturâ orbiculari-lunatâ; septis obsoletè undulatis; siphunculo subcentrali.

Median diameter, 6 inches. Breadth at base of aperture, 4 inches.

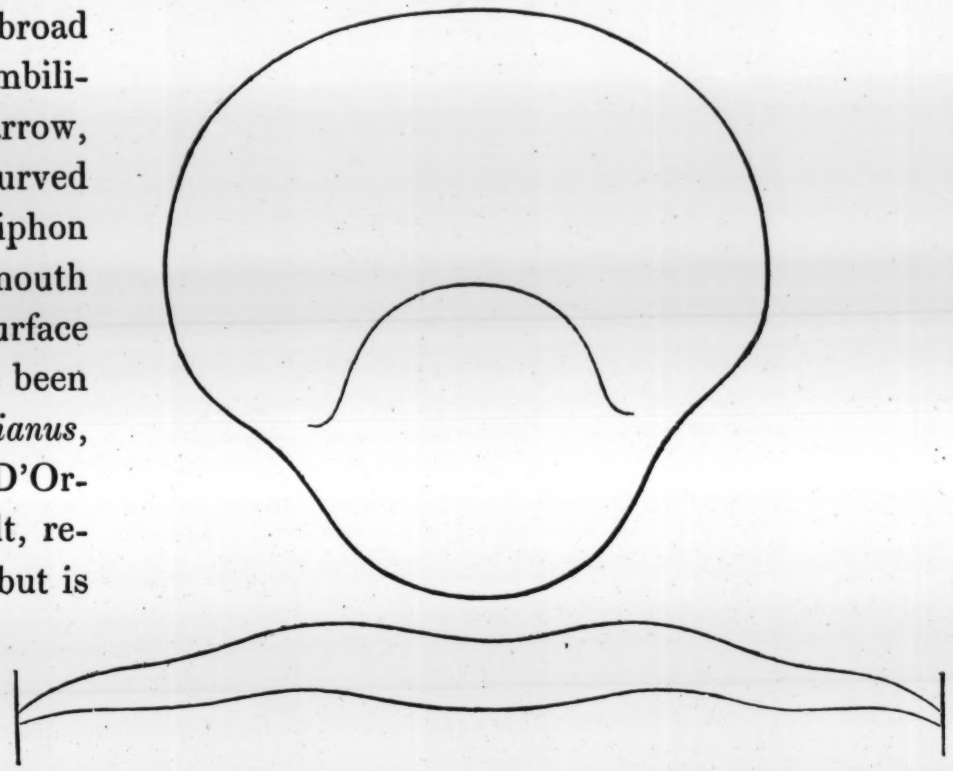
Shell subglobose, much-inflated, slightly umbilicated, externally smooth; the mouth suborbicular and lunate. The chambers have a slight tendency to show a sinuated outline. The siphon is a little nearer to the spire than to the back. The spaces between the chambers and the degree of inflation of the entire shell vary in different specimens. Young examples have a very smooth shell. I cannot distinguish it from the *Nautilus lævigatus*, except in that the chambers of the French species are usually wider. M. D'Orbigny describes his shell as from the "couches moyennes de la craie, à l'étage des craies tufau et au grès vert." (D'Orb. P. F. Terrains Crétacés, vol. i. p. 84. pl. 17.)

Locality, Pondicherry.

2. *Nautilus sphæricus*, sp. nov.

N. testâ globosâ, inflatissimâ (lævigata?), umbilicatâ; aperturâ latissimâ, lunatâ, angustatâ; septis arcuatis; siphunculo excentrico.

Median diameter, 4 inches. Breadth at base of aperture, $4\frac{7}{10}$ inches.



A very globose shell, as broad as long. It is distinctly umbilicated. The chambers are narrow, and the septa are slightly curved towards the umbilicus. The siphon is ventrally excentric. The mouth is lunate and narrow. The surface of the shell appears to have been smooth. *Nautilus Bouchardianus*, described and figured by D'Orbigny from the French gault, resembles the Indian species, but is not so globose, and the siphon is differently placed.

Locality, Pondicherry.

3. *Nautilus clementinus*, D'Orbigny?

N. testâ subglobosâ, inflatâ, reticulatâ, umbilicatâ; aperturâ latè lunatâ; septis simplicibus.

Median diameter, $2\frac{4}{10}$ inches. Breadth at base of aperture, $1\frac{7}{10}$ inch.

A subglobose inflated shell, distinctly umbilicated, having a wide lunate mouth and very simple chambers. The surface is transversely furrowed by numerous regular shallow sulcations, separated by acute ridges, and reticulated by less strongly marked longitudinal striations. The specimens are much injured, and the position of the siphon is not distinctly seen. I cannot distinguish between the Indian fossil and the young of *Nautilus clementinus* (D'Orb. Pal. Franc.; Ter. Crét. i. pl. 13 *bis*), as described and figured by D'Orbigny from the French gault.

Locality, Verdachellum.

4. *Nautilus Delphinus*, sp. nov.

N. testâ compressâ, discoideâ (lævigatâ?), subumbilicatâ; dorso rotundato; aperturâ lanceolatâ; septis sinuatis, lateraliter in medio lobo triangulari subacuto ad basim superiorem angulato; siphunculo ?

Median diameter, $3\frac{6}{10}$ inches. Breadth at base of aperture, $2\frac{3}{10}$ inches.



This species is much-compressed, especially dorsally: the angles of the mouth project so as to give the aperture a hastate or triangular form. The surface of the only specimen is too much worn to be made out clearly. The septa are remarkably sinuous; laterally and nearly in the centre they make a bend, the sweep of which is abruptly curved and directed towards the umbilicus so as to form a sort of triangular lobe, resembling in form a porpoise's fin, and angulated at its superior base, whence the line crosses the back in a slightly undulated curve. It belongs to a group of forms mostly oolitic. The *Nautilus sinuatus* of Sowerby and *Nautilus biangulatus* of D'Orbigny are its nearest allies.

Locality, Pondicherry.

Genus Ammonites, Auctorum.

There are twenty-three species in the Pondicherry collection. They belong to the following sections, as established by Von Buch and D'Orbigny:—

1st, *Fimbriati*, a group especially characteristic of the lowest part of the cretaceous system and extending into the oolites. To this division belong *Ammonites Vishnu* and *Ammonites Brahma*.

2nd, *Ligati*, a group of which all the known species are cretaceous, and the greater number from the lowest beds. The Pondicherry species of this division are no fewer than eight, most of them closely allied to fossils of the beds called in France "Lower Neocomian."

3rd, *Heterophylli*, a group almost entirely confined to the lowest portion of the cretaceous system. Seven Pondicherry Ammonites belong to this division, many of them extremely near French Neocomian species.

4th, *Flexuosi*, a lower cretaceous group of small extent. One Indian fossil, the *Ammonites Egertoni*, belongs to it.

5th, *Dentati*, an extensive group of lower cretaceous forms. Two of the Indian species belong to this division.

6th, *Clypeiformi*, lower cretaceous and oolitic. There is one Pondicherry species, *Ammonites Siva*.

7th, *Armati*, a group of upper oolitic forms. *Ammonites Menu* appears to belong to this section.

8th, A single Ammonite, *A. Rembda*, represents a type of forms as yet uncharacterized, and which I propose to call *Lævigati*.

Fimbriati.

1. *Ammonites Vishnu*, nov. sp. Pl. VII. fig. 9.

A. testâ compressâ, lævigatâ, transversim costatâ, costis simplicibus, distantibus, prominentibus; dorso rotundato; aperturâ ovato-cordatâ.

Diameter, $4\frac{1}{4}$ inches.
Diameter of disc formed by the inner whorls, 2 inches.
Medium thickness of outer whorl, 1 inch.

Whorls five or six, rounded, forming a concave disc, which however is not deep in the centre. Each whorl is banded at intervals by strong rounded ribs, those towards the mouth on the outermost whorl becoming fewer and more distant, and presenting the character of oral varices. There are fifteen on the outer whorl. The surface of the shell appears to have been smooth. The mouth is broadly ovato-cordate. The sutures are plainly seen on the second volution. The young shell was probably ribless.

In the specimen figured, the sutures of the chambers are visible only on the exposed portion of the second whorl. The lateral lobes are pinnate and bifurcate, and appear to have been three or four in number. Their relative arrangement is not exposed.

The cast is deeply furrowed in the region of each varicose rib, and undulated beneath the intermediate ribs.

This species approaches very nearly the Neocomian *Ammonites honoratissimus* of M. D'Orbigny (Ter. Crét. i. plate 37). It differs in being less compressed; in having more numerous transverse ribs, especially on the second whorl; and in the form of the aperture, which in the French species is oblongo-ovate.

Locality, Pondicherry.

2. *Ammonites Brahma*, nov. sp. Pl. VIII. fig. 1.

A. testâ compressâ, lævigatâ, transversim sulcatâ costatâque; sulcis marginatis distantibus, costis numerosis lateraliter obsoletis; anfractibus sex, internis acutè tuberculatis; dorso rotundato; aperturâ reniformi.

Diameter	4 inches.
Diameter of inner whorls	2 inches.
Median breadth of outer whorl . . .	$1\frac{1}{4}$ inch.

Shell compressed; whorls six, smooth, convex, the outermost transversely sulcated and strongly ribbed at intervals; the strong ribs six or seven in number, the intermediate ones continuous over the rounded back, but obsolete at the sides: the inner whorls with fewer sulcations, but ornamented with acute tubercles; the umbilicus is rather deep; the aperture is transversely reniform. Young shells

have their backs smooth and all the whorls tubercled. [This character especially distinguishes *A. Brahma* from *A. Vishnu*.]

The sutures of the chambers resemble those of *A. Vishnu*. The dorsal lobe is very large and ramified, much exceeding the superior lateral, which is bifurcated. The saddles are in pairs, three or four in number, and much-branched. The line of lobes is very oblique.

Locality, Pondicherry.

Ligati.

3. *Ammonites Juilleti*? Pl. VII. fig. 2.

A. Juilleti, D'Orbigny, Pal. Fr. Ter. Cr. i. p. 156. pl. 50. f. 1–3?

A. testâ suborbiculari, lævigatâ, umbilicatâ; anfractibus 5 rotundatis; aperturâ circulari.

	Dimensions of Pondicherry specimen.	Dimensions of a French specimen.
Breadth	$0\frac{7\frac{1}{2}}{12}$ inch.	$0\frac{7}{12}$ inch.
Breadth of outer whorl at the mouth	$0\frac{3\frac{1}{2}}{12}$ inch.	$0\frac{3}{12}$ inch.
Breadth of outer whorl at the commencement of the second	$0\frac{2\frac{1}{2}}{12}$ inch.	$0\frac{2}{12}$ inch.
Breadth of umbilicus	$0\frac{2\frac{3}{4}}{12}$ inch.	$0\frac{2}{12}$ inch.

The above dimensions present the chief differences between an Indian specimen and one from Castellane (in Mr. Pratt's collection) nearly of the same size. The shell is suborbicular and rather tumid; the umbilicus deep; the whorls 5, rounded and apparently smooth. [M. D'Orbigny in a supplementary note on *A. Juilleti* speaks of striated specimens.] The aperture is circular.

The chambers are very much divided. The lateral lobes are two, deeply cleft and bifurcated, especially the superior one, which however is scarcely so long as the deeply divided and much-ramified dorsal. The saddles are deeply bilobed, the dorsal one, which is largest, most regularly. The divisions of the chambers in the Indian species very closely resemble those in the French species. For the present, I cannot safely separate the one from the other. The French *A. Jeannoti* is described by M. D'Orbigny from specimens collected near Gap, in Neocomian marls.

Locality, Pondicherry.

4. *Ammonites Kayei*, sp. nov. Pl. VIII. fig. 3.

A. testâ discoideâ, depressâ, latè umbilicatâ, transversim striatâ sulcatâque, striis minutissimis obliquis; sulcis distantibus paucis; anfractibus 8 planiusculis; aperturâ reniformi.

Diameter	$2\frac{3}{10}$ inches.
Diameter of umbilicus	$1\frac{2}{10}$ inch.
Thickness of outer whorl	$0\frac{7}{10}$ inch.

Shell discoid and resembling a Planorbis in shape; remarkable for the wide con-

cave umbilicus exposing numerous depressed whorls, usually eight or nine in number. These whorls are furrowed at intervals by deep, oblique and slightly undulated furrows of growth, about four of which are seen on the cast of the outer whorl: when the shell is present the furrows are filled up. The surface of the true shell is very finely marked by regular oblique transverse striæ, the interstices of which rise into minute ridges like those seen on the epidermis of many Helices, as *H. pulchellus*. It appears to have been very thin. The back is rounded; the mouth is slightly reniform and very broad.

The chambers of this remarkable species are much divided, there being no fewer than five very narrow and gradually decreasing lobes, more or less trifurcated at their extremities. The intermediate saddles are also narrow and are bifurcated. The dorsal lobe is a little shorter than the superior lateral.

This curious Ammonite, one of the most interesting in the collection, appears to be an extreme form of the group of *Ligati*.

Locality, Pondicherry.

5. *Ammonites Garuda*, sp. nov. Pl. VII. fig. 1.

A. testâ discoideâ, lævigatâ, in umbilico radiatim striatâ; anfractibus 5, ultimo inflato; dorso rotundato, umbilico profundo; aperturâ rotundatâ, subinflatâ.

Diameter	$0\frac{9}{10}$ inch.
Diameter of outer whorl	$0\frac{4}{10}$ inch.
Thickness	$0\frac{11}{20}$ inch.

Whorls about five, gradually increasing, and the outer one somewhat inflated towards the aperture. The shell appears in some specimens to have been striated, and in others smooth: in the larger specimens radiating striæ are seen in the umbilicus proceeding from the suture of the whorls.

The chambers are very complicated in old specimens, comparatively simple in young (as figured). The lateral lobes are four, the superior ones bifurcated, their divisions trifurcated. The dorsal lobe, which is as long or longer than the superior lateral, is deeply cleft, the branches slender and trifurcating. The saddles are more or less three-branched, their lobules ovate and very regular.

Locality, Pondicherry.

6. *Ammonites Soma*, sp. nov. Pl. VII. fig. 7.

A. testâ discoideâ, lævigatâ, subcompressâ, sulcatâ, sulcis distantibus, anfractibus 4–5, ultimo lato; umbilico parvo, profundo; dorso rotundato; aperturâ suborbiculari, subcompressâ.

Diameter	$0\frac{10}{12}$ inch.
Diameter of outer whorl	$0\frac{4}{12}$ inch.
Median thickness	$0\frac{3}{12}$ inch.

Whorls about five, suddenly increasing, but somewhat compressed, though thick. Surface apparently smooth, becoming interrupted at distant intervals by oval furrows of growth. Umbilicus very narrow but deep, especially within the second whorl. [In its ally, *A. Garuda*, the outer whorl rises much above the second.] Mouth not dilated, and hence presenting a suborbicular form, somewhat oblong from the compression of sides, so as to be longer than wide. [The mouth of *A. Garuda* is wider than long.]

Chambers very complicated. Lateral lobes 3 or 4, the superior lateral largest, much-divided, trifurcated, and exceeding in length the dorsal. Dorsal lobe deeply cleft, each division branching into antler-like ramifications. Siphonal saddle oblong. Dorsal and lateral saddles bifurcated, much-ramified, divisions narrow. The ramifications of the sutures of the chambers in this Ammonite are much more complicated than in *A. Garuda* of the same size.

Locality, Pondicherry.

7. *Ammonites Chrishna*, sp. nov. Pl. IX. fig. 2.

A. testâ compressâ, discoideâ, lævigatâ; anfractibus depressis, 4–5, ultimo radiatim costato, costis dorsaliter obsoletis; dorso transversè crebrisulcato, sulcis lateraliter obsoletis; aperturâ lunatâ.

Diameter	4 inches.
Median diameter of last whorl . . .	$1\frac{1}{10}$ inch.
Thickness	$1\frac{2}{10}$ inch.

Shell much-depressed, the last whorl gently increasing and leaving the inner whorls exposed, ornamented with ten or eleven radiating curved ribs, which commence above the inner margin, and become obsolete before they reach the back. The back is crossed by numerous sulcations, which however are not continued down the sides, but cease suddenly: there are about thirty-one of these on a specimen of the above dimensions. The umbilicus is shallow, and narrow when compared with the breadth of the shell. The mouth appears to have been ovate.

The lobes of the chambers are about three on each side, and more or less regularly trifurcated. The superior lateral is largest, and greatly exceeds the dorsal, which is wide, and terminates in two not very long spreading branches. The saddles are narrow and bifurcated. The lateral is as large as, or exceeds the dorsal. The auxiliary lobes and saddles suddenly decrease.

This species is related to *Ammonites Carteroni*, a French Neocomian species.

Locality, Pondicherry.

8. *Ammonites Ganesa*, sp. nov. Pl. VII. fig. 8.

A. testâ discoideâ, lævigatâ, dorso rotundato, umbilico profundo, anfractibus 5; anfractu ultimo internè costato-tuberculato; costis 7–8; aperturâ reniformi-subtrigonâ.

Diameter	$1\frac{6}{10}$ inch.
Diameter of outer whorl	$0\frac{7}{10}$ inch.
Breadth	$0\frac{5}{10}$ inch.

Shell discoid, the whorls ornamented with obsolete ribs on their inner sides, forming elongated tubercles immediately over the deep and steep-sided umbilicus. The whorls are five in all, the outermost broader than all the rest together. The aperture is kidney-shaped and inclined to triangular.

The chambers are complicated. The lateral lobes are three or four in number, much-divided, and more or less trifurcated. The dorsal lobe is nearly as long as the superior lateral, deeply divided, and sends out two narrow trifurcated branches which are separated by a quadrangular, oblong, siphonal saddle. The saddles are bifurcated, their branches narrow, deeply separated and much-ramified.

Locality, Pondicherry.

An abnormal form of the section *Ligati*, approaching nearest a group of gault and upper greensand forms of which the *Ammonites peramplus* of Mantell is an example.

9. *Ammonites Cala*, sp. nov. Pl. VIII. fig. 4.

A. testâ discoideâ, lævigatâ, anfractibus $6\frac{1}{2}$ rotundatis; umbilico lato; dorso rotundato; aperturâ reniformi.

Diameter	$1\frac{1}{10}$ inch.
Diameter of outer whorl	$0\frac{4}{10}$ inch.
Thickness	$0\frac{4}{10}$ inch.

Shell resembling in shape *Planorbis corneus*. The whorls are six, and exposed in the wide and shallow umbilicus. The mouth is wide in consequence of the dilatation of the outer whorl.

Chambers with many-lobed partitions. Lobes five or six, more or less trifurcated, rather short, rapidly decreasing towards the umbilicus, and placed in an oblique line. Dorsal lobe large, much pinnate and bifurcate, exceeding the superior lateral. Saddles bifurcated and more or less phylliform in their extreme divisions, equalling the lobes in dimensions, and gradually decreasing towards the umbilicus.

This species is nearly allied to the French Neocomian form, *Ammonites Emerici*. It differs however in the absence of distant sulcations, a character which would separate it from the group *Ligati* were it not so very near in all other respects several species of that section, and in the size of the dorsal lobe and number of the lateral ones; the former being much larger in proportion to the superior lateral, and the number of the latter being fewer than in *A. Emerici*.

10. *Ammonites Durga*, sp. nov. Pl. VII. fig. 11.

A. testâ discoideâ, lævigatâ, compressâ, anfractibus 4, planis, suturis profundis, dorso rotundato, compresso; aperturâ lanceolato-ovatâ.

Diameter	$0\frac{8}{10}$ inch.
Diameter of outer whorl	$0\frac{3}{10}$ inch.
Thickness	$0\frac{4}{10}$ inch.

Shell resembling a flattened species of Planorbis, the outer whorl dorsally compressed so as to exhibit a slight tendency to carination; the inner whorls exposed, 4 or $4\frac{1}{2}$, their inner margin sudden and steep. Umbilicus shallow. Chambers apparently rather simple; lobes about four, the dorsal nearly equalling the superior lateral, which appears to be trifurcated, and not so broad as the former.

Locality, Pondicherry.

Heterophylli.

11. *Ammonites Indra*, sp. nov. Pl. XI. fig. 7.

A. testâ inflatâ, umbilicatâ, striatâ, lævigatâ, anfractibus amplexantibus, dorso rotundato aperturâ dilatatâ, ovatâ.

Median diameter	$3\frac{4}{10}$ inches.
Oral diameter	$4\frac{3}{10}$ inches.
Diameter of outer whorl	$1\frac{4}{10}$ inch.
Thickness	$1\frac{4}{10}$ inch.

Shell resembling an umbilicated Nautilus, much-dilated at the mouth, where the outer whorl becomes also somewhat elongated. Surface minutely striated, though at first glance appearing smooth and polished. The umbilicus is small; in the specimens examined it was hidden by rock. The umbilical side of the outer whorl is rounded and sloping. The sutures are beautifully complicated. The lateral lobes are four or five, gradually diminishing: they are trifurcated and much-divided, springing from very narrow bases. The superior lateral is much the largest, and slightly exceeds the very large, much-ramified and deeply bifurcated dorsal. The saddles are bifurcated, their extreme divisions more or less phylliform: the superior lateral saddle is largest. The partitions are arranged obliquely, and their sutures encroach nearly on each other.

A very distinct and beautiful species, one of the finest in its section.

Locality, Pondicherry.

12. *Ammonites diphylloides*, sp. nov. Pl. VIII. fig. 8.

A. testâ compressâ, lævigatâ; umbilico leviter impresso; anfractibus amplexantibus lateraliter depressis; dorso rotundato; aperturâ ovato-lunatâ.

Diameter	$0\frac{8}{10}$ inch.
Diameter of body-whorl	$0\frac{4}{10}$ inch.
Thickness	$0\frac{3}{10}$ inch.

Resembling *A. Rouyanus* in form, but compressed and not dilated at the mouth.

The surface appears to have been quite smooth. The umbilicus is very small, and not so deep as in the last species. The mouth is ovate and lunate, through the projection of the returning whorl.

The divisions of the partitions are numerous and short. The lateral lobes are seven or eight in number, trifurcated, though but slightly divided, much-dentated and separated by secondary lobes. The dorsal lobe is nearly as long as the superior lateral and broader, bifurcated, each furcation trifurcated and widely spreading. The saddles are bifurcated and their divisions are phylliform.

This Ammonite is very nearly allied to *A. diphyllus*, a French Neocomian species from Senez, and also to *A. picturatus* from the same locality, but I cannot safely identify it with either. I have compared it with specimens of *A. diphyllus* in the collection of Mr. Pratt.

Locality, Pondicherry.

13. *Ammonites Surya*, sp. nov. Pl. VII. fig. 10.

A. testâ compressâ, undulatâ, transversim regulariter sulcato-striatâ; striis ad umbilicum obsoletis; umbilico angustissimo; dorso rotundato; aperturâ elongatâ, compressâ.

Diameter	$2\frac{3}{4}$ inches.
Diameter of outer whorl (largest specimen)	$1\frac{1}{2}$ inch.
Median thickness	$0\frac{1}{2}\frac{3}{0}$ inch.

Shell discoid, much-compressed, so that in young specimens the back has an approach to carination, the outer whorl embracing all the others so as to leave but a very small umbilicus, from which proceed strong undulating ribs, which become obsolete just before they reach the back. The back itself (rounded in adult examples) is crossed by deep regular striæ, which run down the sides on and between the ribs, and become obsolete just before they reach the umbilicus. The mouth is oblong and compressed. The chambers (as seen through the shell of the largest specimen) are very complicated. The lateral lobes are five or six in number, long, slender, ramifying, and trifurcated; the superior lateral much exceeds the dorsal. The saddles are two-branched, the branches much-ramified, the ramifications terminating in ovate phylliform lobules.

A species of the same group with the last, but very distinct from any European forms. *Ammonites difficilis*, a French Neocomian species, figured by D'Orbigny from the Basses Alpes, is perhaps its nearest known ally.

Locality, Pondicherry.

14. *Ammonites Nera*, sp. nov. Pl. VIII. fig. 7.

A. testâ valdè compressâ, umbilicatâ, anfractibus amplexantibus planis, ultimo transversè striatâ, striis tenuissimis, regularibus, continuis, simplicibus, ad umbilicum obsoletis; dorso rotundato; aperturâ oblongâ, compressâ.

Diameter	$0\frac{8}{10}$ inch.
Diameter of outer whorl	$0\frac{3}{10}$ inch.
Thickness	$0\frac{2}{10}$ inch.

Shell discoid and extremely compressed, the whorls rapidly increasing in breadth; the outer one embracing all the others and leaving a small umbilicus. The back is rounded and crossed by exquisitely fine regular and continuous striæ, which run along the sides towards the umbilicus, but become obsolete before they reach it. At the umbilicus are indications of a few short radiating furrows. Mouth oblong, and most dilated superiorly. Very young shells appear to have been smooth and much thicker in their proportions.

Chambers very complicated and elegant in their pattern. The lateral lobes four or five, very narrow and long, much-divided, and more or less irregularly trifurcated at their extremities. The superior lateral extends much beyond the dorsal, and is much wider than the next lateral. The saddles are bifurcated, narrow, and beautifully crenated. The partitions of contiguous chambers encroach upon one another.

Very near *Ammonites semistriatus*, D'Orbigny, and some allied species from the Neocomian beds of Castellane.

Locality, Pondicherry, apparently rare.

15. *Ammonites Yama*, sp. nov. Pl. VII. fig. 4.

A. testâ compressâ, lævigatâ?, anfractibus planatis, umbilico angustissimo, dorso compresso, rotundato; aperturâ compressâ, oblongâ.

Diameter	$0\frac{8}{12}$ inch.
Diameter of outer whorl	$0\frac{3}{12}$ inch.
Median thickness	$0\frac{2}{12}$ inch.

Shell very much worn in the only specimen in the collection, much-compressed, the sides of the whorls being almost flat, very gently increasing towards the mouth, which consequently has an oblong compressed form, distinguishing it from all the species in the collection. The outer whorl embraces all the others so as to leave but a narrow umbilicus. The chambers are not visible. This species is nearly allied to *Ammonites Varuna*, but easily distinguished by the peculiar form of the aperture and the equality of the whorls.

Locality, Pondicherry.

16. *Ammonites Varuna*, sp. nov. Pl. VIII. fig. 5.

A. testâ discoideâ, depressâ, lævigatâ, anfractibus 4 depressis, umbilico angustissimo, profundo; dorso rotundato; aperturâ dilatatâ, rotundatâ, subtrigonâ.

Diameter	$0\frac{5}{10}$ inch.
Diameter of outer whorl	$0\frac{2}{10}$ inch.
Thickness	$0\frac{3}{20}$ inch.

Shell discoid, compressed, the outer whorl embracing the others, so as to leave a very narrow and deep umbilicus, in which the inner whorls are seen separated by a deep suture. The surface appears to have been smooth. The aperture is oblong and inclined to become triangular; the angles are rounded off.

The chambers present four lateral lobes and as many saddles. The superior lateral is very much larger and more divided than any of the others, and extends beyond the dorsal: it is deeply trifurcated and much-denticulated. The dorsal lobe is broad and square, bifurcated at the end, the furcations tridentated and separated by a short square siphonal saddle. The saddles terminate in equal divisions, the lobules being more or less phylliform.

Locality, Pondicherry. A connecting link between the *Ligati* and *Heterophylli*.

17. *Ammonites Rouyanus*, D'Orbigny. Pl. VIII. fig. 6.

A. Rouyanus, D'Orb. P. F. Ter. Crét. i. p. 362. pl. 110. fig. 3–5.

A. testâ inflatâ, lævigatâ (sub lente striatâ), umbilico impresso; anfractibus amplexantibus, convexis; dorso rotundato, demum striato; aperturâ dilatatâ, rotundatâ.

Diameter	$1\frac{1}{10}$ inch.
Diameter of outer whorl	$0\frac{11}{20}$ inch.
Median thickness of outer whorl . . .	$0\frac{11}{20}$ inch.

Fragments show that it grows to twice this size.

Shell resembling a Nautilus in form, smooth to the naked eye, but when examined with a lens seen to be minutely striated; shining. The umbilicus is imperforate and impressed. The outer whorl embraces all the others, and gradually increases so as to form a wide, round, trumpet-like mouth. The back is beautifully rounded, and in old specimens is finely striated across.

Lobes of the sutures very numerous (seven or more), gradually diminishing towards the umbilicus. The lateral ones trifurcated and acutely pinnate. Dorsal lobe as large as the superior lateral, bifurcated, the furcations trifurcated. Intermediate pinnated but unbranched auxiliary lobes between the primary ones. Saddles bifurcated, parts nearly equal and terminating in phylliform lobules. Dorsal saddle as large as the superior lateral lobe. Siphonal inter-saddle small, linguiform.

Except in the returning whorls of the Indian species being narrower than they are in M. D'Orbigny's figure of *A. Rouyanus*, I cannot distinguish between them: so prefer identifying the Indian with the French species. The latter is from Castellane.

Locality, Pondicherry.

Flexuosi.

18. *Ammonites Egertoni*, sp. nov. Pl. IX. fig. 1.

A. testâ subcompressâ, lævigatâ, transversim radiato-sulcatâ; sulcis lateraliter obscuris, ad

umbilicum et juxta dorsum prominentibus, in dorso interruptis; dorso rotundato, in medio lævigato; aperturâ ovato-trigonâ, angulis obtusis.

Diameter	$3\frac{3}{4}$ inches.
Length of mouth	$1\frac{3}{4}$ inch.
Thickness at mouth	$1\frac{1}{2}$ inch.
Thickness at second whorl	$1\frac{1}{4}$ inch.

A subcompressed shell of several rounded whorls, the outermost much the largest, and ornamented with ribs which, rising strongly from the umbilicus, become almost obsolete on the centre of the whorl, and reappear in the shape of oblong tubercles on the region of the back; these tubercles are however altogether absent in the last chamber on the adult shell. The back itself is rounded and smooth. The mouth is broadly ovate and subtrigonal.

The chambers are rather complicated. There are three lateral lobes, the superior one largest and trifurcated, as are also the others, but in a less degree. The superior lateral greatly exceeds the dorsal, which is short and two-branched, the branches slender and spreading. The saddles are two-branched, the lateral one being larger than the dorsal.

Locality, Pondicherry. A form connecting such Ammonites as *A. Renauxianus* and *A. radiatus* with the group of which *A. Carteroni*, *A. fascicularis*, and the Indian *A. Chrishna* are examples.

Dentati.

19. *Ammonites Cunliffei*, sp. nov. Pl. VIII. fig. 2.

A. testâ compressâ, undulatâ; dorso compresso, lævigato, lateraliter tuberculato, tuberculis distantibus; umbilico angusto, marginato, margine tuberculato; aperturâ compressâ, supernè truncatâ.

Diameter	$1\frac{1}{10}$ inch.
Diameter of outer whorl	$0\frac{6}{10}$ inch.
Median thickness	$0\frac{4}{10}$ inch.

Shell laterally compressed, the back much depressed and bordered on each side by a row of distant, very prominent tubercles, seven on each side of the outer whorl. The foremost of these is at some distance from the mouth, and in front of it the undulations on the shell are strongest and inclined to bifurcate. There is another row of smaller and closer tubercles on the inner margin of the whorls, which forms a steep and sudden wall round the narrow umbilicus. Consequently the base of the mouth is broad, and the latter assumes an ovato-quadrate form.

The lateral lobes of the chambers are three, much divided and spreading, and more or less trifurcated. The dorsal lobe is oblong and not deeply divided, but branched at its extremity into two short trifurcating arms. It is fully as long or longer than the superior lateral. The saddles are more or less regularly bifur-

cated and much divided though broad (broader than the lobes). Their extreme divisions are rounded, but not foliaceous.

Locality, Pondicherry.

This very distinct Ammonite appears to be rare. It approaches some gault species, and in the form of its back resembles some French Neocomian Ammonites, but is very distinct from all.

20. *Ammonites Pavana*, sp. nov. Pl. VII. fig. 5.

A. testâ compressâ, undulatâ; dorso depresso, lateraliter obsoletè tuberculato; tuberculis distantibus; umbilico angusto, marginibus crenatis; aperturâ compressâ, supernè truncatâ.

Diameter	$0\frac{5}{12}$ inch.
Median diameter of outer whorl . . .	$0\frac{2}{12}$ inch.
Median thickness	$0\frac{2}{12}$ inch.

Shell laterally compressed, the last whorl very large and suddenly increasing to the mouth, ornamented with undulated slightly raised ridges, some of which, at regular intervals, are rather larger than the rest, and rise into tubercles at the margin of the slightly depressed back. The umbilicus is deep and very narrow, and exposes four or five whorls. The chambers are not seen in the only specimen in the collection. It approaches very nearly to the last species (*A. Cunliffei*), but differs from specimens of the same size in having no strong tubercles on the whorls, especially near the umbilicus; the general aspect is also different. It is evidently a young shell, and probably when full-grown exhibits a much squarer back, which, near the mouth, in the specimen before me, is nearly round.

Locality, Pondicherry.

Clypeiformi.

21. *Ammonites Siva*, sp. nov. Pl. VII. fig. 6.

A. testâ compressissimâ, lævigatâ, angustissimè umbilicatâ, anfractibus complanatis, amplexantibus; dorso acutissimè cultrato, integerrimo; aperturâ sagittatâ.

Diameter	$3\frac{1}{2}$ inches.
Diameter of outer whorl	$1\frac{7}{10}$ inch.
Thickness	$0\frac{7}{10}$ inch.

Shell quoit-shaped, the inner whorls concealed, the umbilicus very small. The surface is smooth; a few fine radiating striæ appearing only on the umbilicus. Back compressed and very sharp. Mouth lanceolate.

The divisions of the septa are numerous but short. The lobes gradually decrease towards the umbilicus. The dorsal lobe is largest. They are more or less irregularly bifurcated. The saddles terminate in large phylliform lobules, which are more or less symmetrically arranged, but the terminal lobule is always in advance

of all the others. As the contiguous chambers encroach on each other at the sutures, great complexity is given to the pattern they describe.

The oolitic *Ammonites discus* (Sowerby), the Neocomian *A. clypeiformis* (D'Orbigny), and the *A. Requienianus* (D'Orbigny) of the French 'craie chloritée' are all very near allies of this fine species from Pondicherry.

Armati.

22. *Ammonites Menu*, sp. nov. Pl. X. fig. 1.

A. testâ discoideâ, inflatâ, obsoletè undulatâ, striatâ sulcatâque, sulcis transversis distantibus, marginatis; dorso lato, subquadrato, lateraliter tuberculato; umbilico impresso; aperturâ latâ (lunato-quadratâ?).

Diameter	$2\frac{7}{10}$ inches.
Diameter of outer whorl	$1\frac{1}{10}$ inch.
Median thickness	$1\frac{4}{10}$ inch.

Shell suborbicular, much inflated, smooth or minutely striated, the outer whorls with two series of tubercles, those most dorsal larger than the inner, which have a tendency to be prolonged superiorly into ribs. The back is slightly rounded and free from ribs, but rendered somewhat quadrate by the bordering tubercles. Anteriorly there are two deep sulcations with raised borders, crossing the shell and continuous round the outer whorl. The mouth, which is broken away, appears from the section to have been broad, lunate and somewhat quadrangular, owing to the projecting tubercles. In the young shell the dorsal series of tubercles appears to be wanting.

The chambers are extremely complicated. The lateral lobes are three, of which the superior lateral is much the largest; they are trifurcated and much pinnate. The dorsal lobe is not quite so long as the superior lateral; it is much divided at the sides and separated at the extremity by a short, square, dentated, siphonal saddle. The saddles are as much divided as the lobes and are unequally bifurcated, the furcations deeply crenate and much divided. The nearest allies of this species are oolitic, to which formation all the European species of the division belong.

Locality, Pondicherry.

Lævigati.

I propose to establish a distinct section, under the above name, for Ammonites which have smooth, ribless, compressed sides, and the back encircled by a siphoniferous keel.

23. *Ammonites Rembda*, sp. nov. Pl. VII. fig. 3.

A. testâ compressâ, lævigatâ; latè umbilicatâ; dorso carinato; carinâ simplici, filiformi,

lateribus sulcatis; anfractibus complanatis, ad umbilicum abruptis (aperturâ oblongâ, compressâ).

Diameter?
Diameter of outer whorl . . . . . $0\frac{1}{2}$ inch.
Diameter of exposed part of second volution $0\frac{2}{12}$ inch.

A second but imperfect specimen in Mr. Cunliffe's collection measures about three inches in diameter. The best-preserved specimen of this very remarkable Ammonite is a small one, unfortunately broken, but what remains is very perfect. The whorls are smooth, extremely compressed; the outer one sloping off to the keel; abruptly and perpendicularly depressed at its umbilical margin, which is also the case with the perfectly flat second whorl. The keel which encircles the back is strongest towards the mouth, and almost obsolete on the inner whorls. It is of a pentagonal form, its sides being hollowed out by two grooves. These grooves are obliquely striated, and the striæ are finely punctate. On the cast the keel is rounded and the grooves are punctate only. The mouth was probably oblong and compressed. There are oblique distant sulcations on the cast indicating temporary mouths.

The chambers, so far as seen, present two large but narrow lateral lobes, which are regularly and deeply trifurcated at their extremities. The superior lateral is much the largest, and extends beyond the deeply bifurcated and wide dorsal. The saddles are narrow and bilobed at their extremities; they do not expand so widely as the lobes.

Locality, Pondicherry.

In the Verdachellum collection are four species of Ammonites; of these, two (*A. Buddha* and *A. Sugata*) belong to the section Heterophylli, or perhaps to the section of which I have made *A. Rembda* the type, and two to the Ligati (*A. Gaudama* and *A. Sacya*); the sections to which all belong indicate a cretaceous age for the beds in which they are found. I have named the Verdachellum Ammonites after Buddhist deities, and the greater number of the Pondicherry species after Brahminical gods. In so large a genus as Ammonites mere descriptive names become inappropriate, since no epithet of that kind can be used which may not apply to many species. Hence such an artificial nomenclature as that I have here adopted becomes not only excusable but convenient, since it indicates, without too strongly insisting on, the geographical region in which the species are found.

24. *Ammonites Buddha*, sp. nov. Pl. XIV. fig. 9.

A. testâ depressâ, politâ, lævigatâ, anfractibus amplexantibus; radiato-sulcatâ, costis intermediis regularibus, latis, rotundatis, supra dorsum continuis, dorso rotundato.

Breadth of last whorl . . . . . 2 inches.
Thickness . . . . . $1\frac{1}{2}$ inch.

A fragment of a very beautiful finely-polished Ammonite, the whorls of which appear to have been ornamented with radiating, rather undulating sulcations, separating broad, smooth, rounded ribs which run over the rounded back. The surface is very smooth, but bears traces of minute striæ. It is closely allied to the Columbian *Ammonites Dumasianus*, described and figured by M. D'Orbigny in his 'Geology of South America.'

Locality, Verdachellum.

25. *Ammonites Sugata*, sp. nov. Pl. X. fig. 2.

A. testâ subcompressâ, umbilicatâ, lævigatâ; anfractibus amplexantibus; dorso rotundato, carinato, carinâ elevatâ obtusâ; aperturâ compresso-lunatâ.

Diameter	$1\frac{2}{12}$ inch.
Thickness	$0\frac{1}{2}$ inch.

A Nautilus-like shell, compressed at the sides, rounded at the back, but bearing an obtuse narrow siphoniferous keel. The surface is smooth; the centre is umbilicated; the mouth is oblong and lunate.

It is allied to the *Ammonites alpinus* of the French gault.

Locality, Verdachellum.

26. *Ammonites Sacya*, sp. nov. Pl. XIV. fig. 10.

A. testâ discoideâ, concavâ, lævigatâ, anfractibus 5, rotundatis, minutissimè transversè striatis; costis obscuris distantibus interruptis; dorso rotundato (aperturâ rotundatâ).

Diameter	$1\frac{3}{12}$ inch.
Diameter of last whorl	$0\frac{5}{12}$ inch.
Thickness	$0\frac{5}{12}$ inch.

A Planorbis-like species, with thick round-backed whorls, so coiled as to exhibit a broad and concave umbilicus. The surface of the shell is minutely striated across. The last whorl is crossed at distant intervals by obscure ribs marking periods of growth. The chambers are not visible.

Locality, Verdachellum.

27. *Ammonites Gaudama*, sp. nov. Pl. X. fig. 3.

A. testâ compressâ, anfractibus planatis ad suturam, abruptè rotundatis; ad dorsum, flexuoso-sulcatis; varicibus continuis, in ultimo anfractu distantibus; dorso rotundato (aperturâ ——).

Semi-diameter	$1\frac{11}{12}$ inch.
Thickness	$0\frac{11}{12}$ inch.

A fragment of a very distinct Ammonite, allied to *A. Mayorianus* of D'Orbigny, having flat coiled whorls, which are semi-sulcated; the furrows run across the rounded back. Several varices of growth cross the outer whorl at irregular distances.

Locality, Verdachellum.

28. Besides the above-described Ammonites from Pondicherry, there is a fragment (represented in Pl. VII. fig. 9) which at first sight seemed to be a portion of some Scaphite, but which I now believe to be a part of the outer whorl of an Ammonite allied to some characteristic oolitic forms (*A. Gowerianus* for example). The whorl is very narrow, and has a back much wider than its breadth. The sides are ornamented with fine deep simple ribs, narrower than the furrows between them. Some of these ribs proceed without increasing over the back and round to the other side; others, in the example before us, meet in threes at short but prominent tubercles which are placed at considerable distances from each other along the side of the back. From the dorsal side of each of these tubercles, three or four similar fine ribs spring and run across the back to the opposite tubercle.

This fragment measures 1 inch across the back and $\frac{6}{10}$ths of an inch across the whorl. I have named it provisionally *Ammonites? indicus*.

There is a fragment of a very large Ammonite, but undeterminable, among the specimens from Trichinopoly.

Genus Baculites, Lamarck.

Of this characteristic cretaceous genus, there are two species in the Pondicherry collection, both distinct from all forms hitherto described.

1. *Baculites vagina*, sp. nov. Pl. X. fig. 4.

B. testâ compressâ, angulatâ, lævigatâ, undulatâ; dorso compresso, angusto, plano, marginato; ventre lato, plano; lateribus in medio undulato-tuberculatis; aperturâ obliquâ, sinuatâ.

Length of the most entire specimen . .	$6\frac{1}{10}$ inches.
Breadth at mouth	$1\frac{3}{10}$ inch.
Breadth of back	$0\frac{2}{10}$ inch.
Breadth of belly	$0\frac{6}{10}$ inch.
Thickness at mouth	$0\frac{9}{10}$ inch.
Breadth at mouth of largest fragment .	2 inches.

Shell a long scabbard-like sheath, broad at the mouth and gradually tapering; compressed at the sides, especially dorsally. The back is very narrow and flat, margined along two-thirds of the shell by two very slightly-undulated, obtuse, narrow ridges; from these, for about a third of the breadth, the sides are smooth, or marked only by oblique lines of growth, but in the centre they are undulated by oblique tubercles, which become less numerous and obsolete as the shell becomes narrower. These tubercles are continued slightly to the margin of the broad flat ventral surface. The mouth is very oblique, being produced dorsally into a linguiform process. The upper surface of each of the lateral tubercles is often marked by a little group of groove-like striæ. The cast is very smooth and its angles very obtuse.

The chambers are beautifully marked. There are five lobes and five saddles, all symmetrical. The dorsal lobe is very wide, and its two crenated branches are separated far apart by a wide siphonal saddle. The superior lateral lobe is longer than the dorsal, but not so broad; the inferior laterals are wider than the superior, but not so long. The lateral saddle is longer and broader than the dorsal; the saddles are elegantly, though not deeply, crenate, and the lobes similarly dentate. The ventral lobule is very short, ovate, crenate and unsymmetrical at its extremity.

Locality, Pondicherry. Apparently abundant. Nearly allied to *Baculites incurvatus* of Dujardin, and to the *Baculites anceps* of Lamarck. The form and the more transverse tubercles distinguish it from the former; the tubercles and the conformation of the chambers from the latter.

2. *Baculites teres*, sp. nov. Pl. X. fig. 5.

B. testâ tereti, undique rotundatâ; lævigatâ, leviter undulatâ, striis longitudinalibus obsoletis, aperturâ obliquâ, sinuatâ.

Length (of largest fragment)	2	inches.
Maximum breadth	$0\frac{1}{4}$	inch.

Shell completely cylindrical, gently tapering, marked with obsolete regular longitudinal striæ, which are not always clearly visible, and obscure undulating oblique transverse folds. The chambers are not visible in the specimens examined. This remarkable and very distinct Baculite appears to be the analogue of the *B. neocomiensis* of D'Orbigny.

Locality, Pondicherry.

Genus Turrilites, Lamarck.

To this genus probably belongs a Planorbis-like cast of four contiguous whorls, which are convex, rounded, and obscurely undulated: the aperture is round. I have named it provisionally *Turrilites planorbis*. It measures $\frac{5}{12}$ths of an inch across, and the last whorl is $\frac{2}{12}$ths of an inch thick. Pl. IX. fig. 5.

Genus Hamites, Parkinson.

The Hamites in this collection appear all to belong to a group having widely-apart spiral terminal volutions, a character of the genus *Ancyloceras* of D'Orbigny. But all M. D'Orbigny's species of *Ancyloceras* have the lobes of their chamber-partitions divided into "parties impaires," whereas all the Pondicherry species have their lobes as in *Hamites*, divided into "parties paires," *i. e.* bifurcated instead of trifurcated. I regard *Ancyloceras*, however, as only a section, and scarcely even that, of *Hamites*, to which *Crioceras*, or at least a part of that genus*,

* See Morris on the genus *Ancyloceras* in Annals of Nat. Hist. vol. xv. p. 30.

may as well be united, and it will be seen that among the following species we have some which assuredly commence life in the form on which M. D'Orbigny has founded his genus *Helicoceras*.

1. *Hamites subcompressus*, sp. nov. Pl. XI. fig. 6.

H. testâ elongatâ, compressâ, crebricostatâ, costis subdistantibus, continuis, simplicibus, obtusis, regularibus, sulcis oralibus interruptis.

Circumference of largest specimen, $1\frac{7}{10}$ inch.

Shell presenting an elliptical section, compressed at the sides, ornamented with encircling ribs which are very regular, and separated by shallow furrows, each of which is about three times the breadth of a rib. At intervals they are interrupted by deep and broad sulcations, indicating stages of growth. The sutures show that the chambers were of no great dimensions, though separated by complicated partitions. Both lobes and saddles are bifurcated and even. The pinnations of the lobes are not deep, hence their margins are but slightly denticulated and the interspaces broad.

Locality, Pondicherry.

2. *Hamites tenuisulcatus*, sp. nov. Pl. XI. fig. 3.

H. testâ elongatâ, rotundatâ, crebricostatâ; costis numerosissimis, filiformibus, continuis, obliquis, regularibus, simplicibus.

Circumference of largest specimen, $2\frac{1}{10}$ inches.

Shell ornamented with very fine and closely-ranged thread-like ribs, which run obliquely though regularly, and are slightly rounded at their summits. In some of the specimens they are interrupted at distant intervals by varices and furrows, indicating arrests of growth. The interstices are narrow, shallow and smooth. All the specimens are more or less curved, some very slightly, others suddenly. The posterior extremity terminates in an obliquely-coiled helicoid spire. The sutures of the chambers are well seen in one of the most curved examples. From it we know the chambers to have been distant, and the partitions divided into evenly furcated lobes and saddles. The largest saddle is the superior lateral; the pinnations of the lobes are not deep, but the larger divisions are wide-spreading. On the whole, the sutures are more complex than in the last species.

Locality, Pondicherry: frequent.

3. *Hamites indicus*, sp. nov. Pl. XI. fig. 4.

H. testâ elongatâ, rotundatâ seu subcompressâ, crebricostatâ; costis continuis, regularibus, simplicibus, subacutis, approximatis (nucleo obtusis).

Circumference of largest specimen, 2 inches.

This Hamite differs from *large-sulcatus* in having much more frequent ribs,

which are in other respects similar to those of the first-described species. The sutures of the chambers are very similar, but the saddles are much more unequal and the lobes more deeply divided. It terminates like the next species in a loose oblique spiral of several whorls.

Locality, Pondicherry.

4. *Hamites large-sulcatus*, sp. nov. Pl. XI. fig. 1.

H. testâ elongatâ, rotundatâ, transversim crebricostatâ, costis continuis, prominentibus, subobliquis, simplicibus, regularibus, distantibus, acutis (in nucleo obtusiusculis).

The surface of this Hamite is barred by very regular sharp ribs, which in some specimens are arranged more or less obliquely. The sulcations between the ribs are quite smooth and rounded. The section of the shell is round, or very slightly compressed. Most of the fragments are straight, but a few are segments of a considerable curve, which shows that the termination posteriorly was spiral. The largest and most curved specimen bears two oral varices. The sutures are seen on some small fragments; they are composed of six lobes and six saddles, both lobes and saddles bifurcated, and not very deeply pinnate. The superior lateral lobe is larger than the dorsal.

There are specimens in the collection of various sizes; the largest measures $2\frac{6}{10}$ inches in circumference.

This species appears to be common at Pondicherry.

5. *Hamites rugatus*, sp. nov. Pl. XI. fig. 2.

H. testâ elongatâ, subcompressâ, transversim crebricostatâ, costis continuis, prominentibus, subobliquis, simplicibus, regularibus, obtusiusculis (in nucleo rotundatis).

Diameter of largest specimen $5\frac{2}{10}$ inches.

This species, which grows to a great size, is encircled by very numerous, prominent and closely-placed ribs. The posterior extremity becomes suddenly spiral, so as to form, when young, a species of the genus *Helicoceras* of M. D'Orbigny. The spire is of three oblique turns, placed quite apart from each other. The partitions of the chambers are very complicated, the lobes and saddles being narrow and much pinnated. They are doubly bifurcated and even.

Locality, Pondicherry.

6. *Hamites nereis*, sp. nov. Pl. X. fig. 7.

H. testâ elongatâ, arcuatâ, compressâ, transversè costatâ, costis frequentibus, interstitiis angustioribus, in dorso subinterruptis; dorso canaliculato.

Circumference of largest specimen $0\frac{9}{10}$ of an inch.

Shell compressed, especially at the back, which is channeled so as to interrupt

the ribs, sometimes entirely and sometimes only imperfectly. Sulcations of the sides twice as broad as the simple and prominent ribs.

Locality, Pondicherry.

7. *Hamites undulatus*, sp. nov. Pl. X. fig. 6.

H. testâ tereti, elongatâ, arcuatâ, transversè costis obscuris undulatâ.

Circumference of largest specimen $0\frac{6}{10}$ inch.

A very slender pipe-like species, distinguished from all the others by its round, smooth, undulated surface.

Locality, Pondicherry.

Genus Ptychoceras, D'Orbigny.

Of a species of this interesting and curious genus, established by M. A. D'Orbigny, there are numerous fragments, beautifully preserved, in the Pondicherry collections. The known European species of Ptychoceras are from the lowest beds of the Cretaceous system.

Ptychoceras sipho, sp. nov. Pl. XI. fig. 5.

P. testâ elongatâ, lævigatâ, undulato-plicatâ; plicis prope aperturam frequentioribus.

Length of longest specimen 4 inches.

Median circumference $1\frac{1}{2}$ inch.

The shell is round, straight for the greater part of its length, and tapers posteriorly; at its widest part it makes a sudden crook-like curve to form the aperture. This portion is more frequently plicated, and the plications stronger than at the straight portion; posteriorly it seems to have made a similar sudden curve; in the younger specimens, indeed, so sudden, that the two parts of the crook are touching. The bend below is striated transversely. The nature of the final termination has not been seen.

The chambers present six lobes and six saddles comparatively (with *Hamites*) very simple, and not differing very greatly in size. The dorsal and ventral lobes are largest. The dorsal, as well as the laterals (which are equal), are bifurcated, each furcation slightly bidentate; the ventral is trifurcate. The saddles are broader than the lobes, and composed of two nearly equal, broad, emarginate (bi-lobuled) branches.

Locality, Pondicherry.

Genus Belemnites, Lamarck.

Of this genus there are in the Pondicherry collection,—

1. The chambers and part of the sheath of a middle-sized conical species, but indeterminable. The nucleus is represented in Pl. IX. fig. 4.

2. Semi-compressed pipe-like fragments, equal in dimensions throughout, evidently closely allied to the *Belemnites? ambiguus* of Morton. I have provisionally named them *Belemnites? fibula*. The figure (Pl. IX. fig. 3) represents the form of the specimen of the natural size.

Gasteropoda.

In the following descriptions of the fossil gasteropodous mollusca of Southern India, I have described under each genus all the species of cretaceous age belonging to it in the collection, whether from Pondicherry, Trinchinopoly, or Verdachellum. It will be seen that all the species are new, as might indeed have been expected in this group. The allies of many are to be found among European cretaceous fossils, but others are, if anything, more nearly allied to tertiary and recent forms. Several belong to genera hitherto considered of very recent creation. The interpretation of these very remarkable peculiarities will be found in the second part of this report.

The genera are arranged in what I consider the sequence of their alliance. The arrangement differs considerably from that which is usually adopted. I commence with *Trochus* and its allies (*Pleurotomaria*? *Nerita* and *Phasianella*), because, among all the genera to be passed in review, these are, in many respects, most highly organized. In them we find indications of a higher organisation, exhibited in the characters of the eyes, tentacula, and appendages of head and body. *Natica* will be found far removed from its usual but incorrect association with *Nerita*; its true position, as is evident to any one who studies and understands the animal, being close to *Bulla*, where also *Tornatella* must be placed, its animal being still more similar to that of the last-mentioned genus.

Genus Trochus, Linnæus.

1. *Trochus arcotensis*, sp. nov. Pl. XIII. fig. 9.

T. testâ latè conicâ (umbilicatâ), anfractibus 5 complanatis, æqualiter (5) striatis, transversè obliquè-striatis, ad suturas depressis, ultimo anfractu margine basali acuto, basi planâ, concentricè crenato-striatâ; aperturâ quadrangulari.

Height $0\frac{4}{12}$ inch. Breadth $0\frac{5}{12}$ inch.

A conical flat-whorled shell, resembling some varieties of *Trochus cinereus* in shape. The whorls are five, and are ornamented by a few spiral thread-like ribs with obliquely striated interstices. The striæ run over them, and slightly crenulate the ribs. The base is flat, spirally grooved and ornamented like the upper portion of the basal whorl. There appears to have been an umbilicus, possibly

with a crenated margin like a *Solarium*. The mouth is oblique and quadrangular. The cast is smooth.

Locality, Pondicherry. This species approaches more nearly certain recent *Trochi* than any fossil ones with which I am acquainted.

2. *Trochus radiatulus*, sp. nov. Pl. XIII. fig. 11.

T. testâ conoideâ, anfractibus (6) tumidis, ad suturam depressis, obliquè striatisque (striis subdistantibus), in medio lævigato; ultimo anfractu margine subangulato; umbilico margine subcrenulato; basi convexiusculâ, radiato-striato; aperturâ subangulatâ.

Height $0\frac{3}{12}$ inch. Breadth $0\frac{3}{12}$ inch.

A very pretty little species, resembling the recent *Trochus Adansoni* in general aspect. The whorls are tumid and slightly flattened at their summits, where they are ornamented by rather distant, oblique, deep radiating striæ; these are continuous with fine lines of growth, which run across the apparently smooth sides, and on the basal whorl meet and again become deep around the umbilicus. The aperture is slightly angulated.

Locality, Pondicherry.

3. *Trochus Rajah*, sp. nov. Pl. XIII. fig. 12.

T. testâ conoideâ, anfractibus (6) tumidis, subangulatis, supernè depressis, obliquè-plicatis, plicis distantibus (in anfractibus superioribus incompletis) longitudinaliter sulcato-striatis; basi convexâ; aperturâ quadrangulari.

Height 1 inch. Breadth $0\frac{10}{12}$ inch.

A conical Cirrus-like species, presenting very distinct characters. The whorls are ventricose and slightly angulated. The shell is ornamented with oblique distant folds crossed by spiral sulcations. The base appears to have been slightly perforated; the aperture is quadrangular. The crest is quite smooth and slightly undulated beneath the folds. In the specimen preserved very little of the shell remains.

Locality, Pondicherry.

4. *Trochus rotelloides*, sp. nov. Pl. XIII. fig. 10.

T. testâ depressissimâ, spiraliter striatâ, anfractibus superioribus planis, ultimo compresso rotundato; basi umbilicatâ, spiraliter striatâ.

Height $0\frac{8}{12}$ inch. Breadth $1\frac{2}{12}$ inch.

A much-depressed Rotella-like shell, but having a deep and well-marked umbilicus. Above it is lenticular, and the suture very shallow: beneath it is slightly convex. The entire shell appears to have been spirally grooved. The only specimen is not in good state. It is, however, easily distinguished from any of its allies.

Locality, Pondicherry.

Genus Pleurotomaria, Defrance.

1. *Pleurotomaria indica*, sp. nov. Pl. XIII. fig. 13.

P. testâ conicâ, elevatâ, anfractibus 7, complanatis, in medio vix convexiusculis, spiraliter sulcato-striatis; basi planâ, angulatâ, striatâ; aperturâ angulatâ.

Height $1\frac{9}{12}$ inch. Breadth $1\frac{5}{4}$ inch.

A pyramidal shell, with nearly flat whorls, spirally striated. The spiral sulcations are usually arranged in pairs between two broader thread-like ridges, of which there are about four on each side of the median furrow. The ridges on the summits of the whorls near the suture are strongest. The base appears to have been umbilicated, but the umbilicus is obscured by rock in the only specimen brought home.

In general form and details of sculpture this species approaches the *Pleurotomaria gigantea* of the English lower greensand, and still more nearly the *Pleurotomaria Pailletiana* of the neocomian beds of France.

Locality, Pondicherry.

2. *Pleurotomaria verdachellensis*, sp. nov. Pl. XIV. fig. 8.

P. testâ conicâ, latâ, anfractibus 7–8, convexis, subcarinatis, spiraliter striatis, transversè obliquè-sulcatis; basi marginato, margine incrassato.

Height $2\frac{2}{12}$ inches. Breadth 3 inches.

A conical but slightly depressed shell, with convex whorls, which are almost carinated in the centre. They are spirally striated with rather distant striæ on each side of the narrow mesial furrow. The base is bounded by a thickened margin. Transverse oblique wrinkles run across the whorls from either edge, and meet, forming an angle at the mesial furrow.

It is allied to several French species from the Craie chloritée.

Locality, Verdachellum.

Genus Nerita, Linnæus.

1. *Nerita ornata*, sp. nov. Pl. XIII. fig. 5.

N. testâ subglobosâ, ovatâ; spirâ parvâ, depressissimâ, anfractibus tribus, ultimo supernè obliquè undulato-sulcato, in medio granulato, infernè obsoletè spiraliter sulcato; aperturâ semilunari, labro lato, lævi.

Diameter $1\frac{1}{2}$ inch. Height $1\frac{3}{10}$ inch. Maximum breadth of aperture $1\frac{2}{10}$ inch.

Shell thick, subglobose, transversely ovate, with three volutions, those of the spire minute. The last whorl sculptured in a remarkable manner, its uppermost part being ornamented with deep-waved sulcations, which are succeeded in the centre of the whorl by obscure granulations, whilst the lower portion is spirally grooved, the grooves becoming obscure. The granulations of the middle part are

doubtless produced by the spiral grooves crossing the extremities of the oblique sulcations and their intermediate ridges. The pillar-lip is broad and smooth. In most of the specimens it is concealed by rock, so that the shell presents the aspect of a Neritopsis.

Locality, Pondicherry, where it appears to be common.

2. *Nerita munita*, sp. nov. Pl. XII. fig. 15.

N. testâ late ovatâ, depressâ, spirâ parvâ exsertiusculâ: anfractibus 4 lævibus, ad suturam latè sulcatis, sulco plano, fortè marginato; aperturâ semilunari.

Length $1\frac{1}{2}$ inch. Breadth $0\frac{2}{2}\frac{3}{4}$ inch.

An ovate smooth shell, with a very small and low spire. The whorls are carinated near the suture by a fold which runs along the spire like a little wall. The space between this fold and the suture is flat, not excavated. The characters of the pillar-lip are concealed by rock. It is a very distinct species, and cannot be compared with any fossil with which I am acquainted.

Locality, Pondicherry.

3. *Nerita oviformis*, sp. nov. Pl. XII. fig. 13.

N. testâ ovatâ, globulosâ, inflatâ; spirâ brevi, obtusissimâ; anfractibus 3 lævibus; aperturâ ovato-pyriformi.

Length $1\frac{1}{2\,4}$ inch. Breadth $0\frac{1\,0}{1\,2}$ inch.

A smooth egg-shaped shell with a very obtuse spire, the distinction between the whorls marked only by the suture. The characters of the pillar-lip are concealed by rock. It is as distinct from described fossil forms as the last species.

Locality, Pondicherry.

4. *Nerita compacta*, sp. nov. Pl. XV. fig. 6.

N. testâ ovatâ, subglobosâ, lævigatâ (sub lente minutissimè striatâ), spirâ minutâ, obtusissimâ; suturâ impressâ; anfractibus tribus; aperturâ lunato-truncatâ, labro columellari incrassato.

Length $0\frac{1}{2}$ inch. Breadth $0\frac{4}{1\,0}$ inch.

This beautiful and curious little Nerita resembles remarkably some of the varieties of the living *Littorina neritoides*. It is ovato-globose, with a very small and obtuse spire of three whorls, indicated only by the deeply impressed suture. To the eye the surface is smooth, but the lens shows a double striation, consisting of—1st, well-marked regular equidistant lines of growth, and, 2nd, very minute radiating striæ, as if the remains of a glistening epidermis. The mouth is lunate, and truncated by the thickened pillar-lip. Its nearest ally is the species last described.

Locality, Trinchinopoly.

Genus Phasianella, Lamarck.

1. *Phasianella? incerta*, sp. nov. Pl. XIII. fig. 8.

I have applied this name provisionally to a fine fossil shell, from Pondicherry, exhibiting a spire of five gradually decreasing, slightly convex whorls, and a large ventricose, ovate body-whorl. It is smooth, and resembles *Achatina Zebra* in form. The mouth is unfortunately partly concealed and partly broken, but I have little doubt that better specimens will show it to be a *Phasianella*. The specimen figured measured 2 inches in length and $\frac{11}{10}$ across the body-whorl.

Genus Turritella, Lamarck.

1. *Turritella pondicherriensis*, sp. nov. Pl. XIII. fig. 4.

T. testâ elongatâ, crassâ, anfractibus concaviusculis, ad suturas marginatis, incrassatis, rugosis, in medio 4–5 costatis, costis filiformibus, interstitiis striatis; suturis profundis; aperturâ angulatâ, basi carinatâ, planâ.

Transverse diameter of lowest whorl $1\frac{3}{10}$ inch. Height $0\frac{6}{10}$ inch. The largest specimen must have been nearly 5 inches long when entire.

A strong shell, resembling a Nerinæa. The whorls are very flat and concave in the centre, where from four to five thread-like ribs encircle them spirally: the lowermost of these threads is most prominent. The whorls are divided from each other by a very deep suture, which is margined by the thickened and irregular crenated upper margin of the continuous whorl. The base is flat and keeled, and the aperture is quadrangular.

Locality, Pondicherry.

2. *Turritella monilifera*, sp. nov. Pl. XIII. fig. 2.

T. testâ conicâ, anfractibus convexis, transversè 3-costatis; costis granulatis, in anfractibus superioribus æqualibus; costâ inferiori in anfractu ultimo obsoletâ; aperturâ rotundatâ, basi convexâ.

Transverse diameter of lowest whorl $0\frac{8}{10}$ inch. Height $0\frac{1}{2}$ inch.

Shell moderately elongated, tapering, with rather ventricose whorls divided by a deep suture. There is a considerable space between the uppermost transverse ridge of one whorl and the lowermost of another. Of two specimens examined, one had eleven whorls; the other was a fragment of a much larger example.

It is distantly related to the *Turritella granulata* of the Blackdown greensand.

Locality, Pondicherry.

3. *Turritella ventricosa*, sp. nov. Pl. XIII. fig. 3.

T. testâ brevi, anfractibus ventricosis, superioribus 4-costatis, ultimo 9-costato, costis lævibus: aperturâ ovato-rotundâ; basi rotundatâ.

Breadth of last whorl $0\frac{1}{2}$ inch. Height $0\frac{4}{10}$ inch.

A ventricose shell of few whorls (in one instance seven), the last comparatively much the largest. They are banded by distant regular spiral ribs, the uppermost of which is distant from the suture. The mouth is slightly angulated at the base.

Locality, Pondicherry.

4. *Turritella Sowerbii*, sp. nov. Pl. XV. fig. 4.

T. testâ conicâ, anfractibus (9) planis ad suturas angulato-impressis, cingulis tribus, cinctis; aperturâ suborbiculari.

Length $0\frac{4}{10}$ inch. Breadth of last whorl rather less than $\frac{1}{10}$ of an inch.

A tapering shell, with nine whorls, which are flat in the centre, and suddenly and angularly sloped off towards the deep suture. Three filiform ridges wind round the volutions, two forming the edges of the flattened space, and the third occupying its centre. The base is rather convex, and the mouth nearly round. The species is gregarious.

Locality, Trinchinopoly.

Genus Scalaria, Lamarck.

1. *Scalaria turbinata*, sp. nov. Pl. XII. fig. 18.

S. testâ brevi, turritâ, anfractibus 7 ventricosis longitudinaliter costatis, (costis in ultimo anfractu 15) interstitiis striatis; basi carinato; aperturâ suborbiculari.

Length of largest specimen 1 inch. Breadth $\frac{1}{2}$ inch.

A short conical species, having seven ventricose whorls, which are crossed by fifteen rather slender, equal, elevated, continuous ribs, closely packed on the upper whorls. The base is carinated centrally by a spiral rib, below which the longitudinal ribs become less marked. The mouth is slightly angulated by the projection of the basal rib. The interspaces of the ribs are striated. The great breadth of the lowest whorl gives a very conical and distinct form to this shell. There are two specimens in the collection, both from Pondicherry. No recorded cretaceous *Scalaria* resembles it.

Locality, Pondicherry.

Genus Vermetus, Adanson.

1. *Vermetus? anguis*, sp. nov. Pl. XIII. fig. 1.

To this genus in all probability belongs the fragment of an uncoiled spiral, consisting of two loose turns of angulated rugose whorls spirally striated and semiplicated.

Locality, Pondicherry.

Genus Chemnitzia, D'Orbigny.

1. *Chemnitzia undosa.* (*Melanopsis undosa*, G. B. Sowerby, MSS.) Pl. XV. fig. 11.

C. testâ turritâ, anfractibus 9, convexiusculis, regulariter undulato-plicatis; spiraliter tenuè striatis; ultimo basi lævigato, aperturâ pyriformi.

Length 3 inches. Greatest breadth (of body-whorl) 1 inch.

Shell turreted; whorls 9, slightly convex in the centre, depressed, as if by an obsolete spiral groove, near the deep suture. They are crossed by strong ribs or plications which are suddenly bent in the depressed portion of the whorls. The surface of the shell is minutely striated spirally. When observed with a lens, the interspaces of the striæ are seen to be alternately narrower and broader, and to be decussated by very fine striations of growth. There are fifteen plications on the body-whorl. They become obsolete below the middle. The mouth is pyriform.

Locality. This species occurs at Verdachellum and at Trinchinopoly. The forms are identical in both localities.

Genus Cerithium, Adanson.

1. *Cerithium sphæruliferum*, sp. nov. Pl. XIII. fig. 6.

C. testâ turritâ, anfractibus planis, lineis spiralibus tuberculorum, alternis multò majoribus, cinctis; suturis impressis; basi concentricè sulcatâ.

The fragment preserved of this very distinct species admits of measurement only on the second whorl, which is $\frac{4}{12}$ths of an inch in length and $\frac{8}{12}$ths in breadth. This whorl is banded by three series of large bead-like tubercles, separated by as many rows of minute ones. On the body-whorl the row of granules near the suture is the only one much developed, the granules of the other rows being small. On the base, the interspaces of the spiral grooves are not granulated. The sutures separating the whorls are very distinctly marked, and rather wide and deep.

Locality, Pondicherry.

2. *Cerithium scalarioideum*, sp. nov. Pl. XIII. fig. 7.

C. testâ turritâ, anfractibus (7–8) planatis, longitudinaliter (16) costatis, costis nodulosis, sulcis spiralibus decussantibus; suturis profundis; basi lævi, bicarinato, carinis crenulatis distantibus; aperturâ orbiculari, canali angusto.

Entire length $1\frac{2}{12}$ inch. Breadth of second whorl $0\frac{5}{25}$ inch. Length of second whorl $0\frac{5}{25}$ inch.

Shell turreted, gradually tapering, with seven or eight flattened whorls, which

are crossed by sixteen longitudinal ribs, broken into tubercles by the decussation of deep spiral furrows. The whorls are separated by a deep suture. The base bears two crenulated or almost granulated spiral ridges ; the rest of its surface is smooth. The mouth is rounded and the canal narrow.

This species is allied to *Cerithium pustulosum* of D'Orbigny, and *Cerithium Dupineanum* of the same author, both French species, the former from the Craie chloritée, the latter from the Neocomien.

3. *Cerithium Trinchinopolitense*, sp. nov. Pl. XV. fig. 10.

C. testâ brevi, anfractibus 6 ventricosis, angustis, costatis, ultimo magno ; longitudinaliter 12-costatâ, costis spiralibus 4–5 decussantibus ; basi convexâ lævi ; caudâ latâ, brevi.

Length rather less than $\frac{2}{10}$ths inch. Breadth $0\frac{1}{10}$ inch.

A small conical species with very tumid narrow whorls, crossed by strong longitudinal ribs and decussated by spiral furrows. The base is convex and smooth, and the mouth terminates in a broad and short canal. It is nearly allied to some lower greensand forms.

Locality, Trinchinopoly.

Genus Triton, Lamarck.

1. *Triton? atavus*, sp. nov. Pl. XIII. fig. 14.

T. testâ elongatâ, fusiformi, anfractibus (6 an 8?) tumidis, ultimo (1) varicoso ; ore rotundato, caudâ angustatâ.

Length 3 inches. Breadth of body-whorl $1\frac{1}{2}$ inch. Length of aperture without canal 1 inch.

A single very imperfect specimen, the generic position of which is however almost certain and very interesting, since the genus, so far as I am aware, has not been observed in cretaceous rocks before. It resembles in form the common *Triton variegatus* and its allies. The surface is so injured as to render its character uncertain, but there are traces of spiral striæ and also of nodulations in the upper whorls. The varix is distinct.

Locality, Pondicherry.

Genus Murex, Linnæus.

1. *Murex fluctuosus*, sp. nov. Pl. XIII. fig. 19.

M. testâ (brevi) inflatâ ; anfractibus convexis rotundatis, longitudinaliter costatis, spiraliter sulcatisque ; costis prominentibus, distantibus, continuis ; sulcis spiralibus numerosis crenatis, interstitiis elevatis crenatis.

Length of remaining portion of body-whorl $1\frac{3}{12}$ inch. Breadth of body-whorl $1\frac{7}{12}$ inch. Length of second whorl $0\frac{7}{12}$ inch.

A very imperfect specimen of a very well-marked species. The diagnostic character embodies all its features, so far as shown in the example described. Its nearest allies seem to be the shells named by D'Orbigny *Fusus Hieranus* and *Fusus neocomiensis*, both French cretaceous forms.

Locality, Pondicherry.

2. *Murex pondicherriensis*, sp. nov. Pl. XIII. fig. 20.

M. testâ inflatâ, anfractibus convexis, tumidis, ad suturas planiusculis, longitudinaliter spiraliterque decussato-costatis; aperturâ latâ, ovatâ, canali brevi.

Length 1 inch. Breadth of last whorl $0\frac{3}{4}$ inch. Length of aperture nearly $0\frac{3}{4}$ inch.

A ventricose, short-spired shell, with a very large and tumid body-whorl which is crossed by fifteen longitudinal ribs, decussated and rendered strongly nodulose by equidistant spiral ribs. This is also the case in the upper whorls. The mouth is ovate and the canal short and broad.

Locality, Pondicherry.

3. *Murex trinchinopolitensis*, sp. nov. Pl. XV. fig. 7.

M. testâ oblongâ, turritâ, crassâ, anfractibus 6, longitudinaliter costatis, transversè costato-striatis, costis longitudinalibus crassis, prominentibus, variciformibus, supernè subangulatis; aperturâ oblongâ, labro externo incrassato.

Length $1\frac{3}{10}$ inch. Breadth $0\frac{7}{10}$ inch.

Shell oblong, thick, whorls six, those of the spire, which is rather more than half the length of the body-whorl, gradually decreasing and angulated: all, as well as the body-whorl, crossed by strong ribs, which are angulated at some distance from the suture: these ribs resemble varices, are rounded and nearly equal. There are eleven of them on the body-whorl, that at the back of the mouth being strongest and most variciform. They are crossed by regular equidistant spiral cords, which are obsolete above the angle of each whorl. Between each pair of spiral cords are three or four deep spiral striæ; their interstices are minutely fenestrated by lines of growth, which also cross over the spiral threads. The mouth is obscured by stone. The canal was short. The shell has much the aspect of a Triton.

Locality, Trinchinopoly; a single specimen in fine preservation.

Genus Pyrula, Lamarck.

1. *Pyrula pondicherriensis*, sp. nov. Pl. XII. fig. 19.

P. testâ oblongo-pyriformi, spirâ brevissimâ, convexiusculâ, anfractibus 3, costis longitudinalibus spiralibusque regulariter fenestratis: aperturâ (oblongâ) labro externo margine dentato.

Length of largest specimen 3 inches. Breadth $1\frac{1}{2}$ inch.

Shell pear-shaped, oblong, very regular in form and sculpture. The spire is scarcely prominent and of only three whorls. The body-whorl is regularly partitioned by numerous equidistant spiral ribs, decussated by similar longitudinal ones. The spiral ribs proceeding to and projecting from the outer margin of the mouth form denticulations.

Fusus infracretaceus and *Fusus ornatus*, both Neocomian fossils from the Aube, species constituted by M. A. D'Orbigny, are allied, especially the latter, to the Indian fossil, which however comes nearer a cretaceous species figured by Römer.

Locality, Pondicherry.

2. *Pyrula cancellata*, G. Sowerby, MSS. Pl. XV. fig. 12.

P. testâ ventricosâ, crassâ, spirâ brevissimâ conicâ, anfractibus 5, ultimo latè pyriformi, supernè carinato, supra carinam concaviusculo, undulato-striato et spiraliter latè sulcato; labio interno incrassato, reflexo, infernè umbilicato, umbilico lato, marginato.

Length 1 inch. Greatest breadth 9 lines.

Shell broadly pyriform, with a very short spire, the surface marked by undulated striæ and spiral sulcations. The last whorl is strongly carinated above, the space between the carination and the suture sloping but slightly concave. The pillar-lip is broad and spreading. The columella is perforated by a broad umbilicus which is margined superiorly.

"This species somewhat resembles in general form the *Pyrula ficulnea* of the London clay and Calcaire grossier; it may however easily be distinguished by having a longer canal, by the anterior part of the last volution being covered by coarse cancellations, and by its rather open umbilicus." G. B. Sowerby, MSS.

Locality, Trinchinopoly. The only specimen is in bad condition.

Genus Rostellaria, Lamarck.

1. *Rostellaria cancellata*, sp. nov. Pl. XIII. fig. 18.

R. testâ conicâ, spirâ longâ, anfractibus 6, rotundatis, bicarinatis, costis longitudinalibus spiralibusque distantibus reticulatis.

Length $0\frac{11}{12}$ inch. Spire $\frac{1}{2}$ inch. Breadth with lip $\frac{1}{2}$ inch.

A young shell, but easily distinguished by its wide window-like sculpture, formed by the distant spiral ribs crossing other equally distant longitudinal ones. The spire is much produced.

Locality, Pondicherry.

2. *Rostellaria securifera*, sp. nov. Pl. XIII. fig. 17.

R. testâ lævi, spirâ conicâ, anfractibus rotundatis, carinatis, labro externo longè producto, carinato, bihamato (hamis obtusis?).

Breadth of body-whorl with its claw $2\frac{9}{12}$ inches. Narrowest part of claw $0\frac{8}{12}$ inch. Across the hooks about $1\frac{6}{12}$ inch.

A fragment of a large and very distinct species, having a much-produced halbert-shaped outer lip, which is carinated at the back. The surface appears to have been quite smooth. It approaches some gault forms.

Locality, Pondicherry.

3. *Rostellaria palliata*, sp. nov. Pl. XIII. fig. 15.

R. testâ elongatâ, lævissimâ, politâ, spirâ productâ, attenuatâ, labro externo in spiram producto et apicem incrustante.

Largest specimen 2 inches long. Spire 1 inch. Breadth $0\frac{8}{12}$ inch.

A beautiful and very remarkable species, having a spire nearly equal to the body-whorl in length, but, though bare in the young specimen, becoming when full-grown enveloped in the callus-like continuation of the outer lip, which envelopes it so that only the body-whorl and part of the second, third, and fourth volutions are exposed, the apex being entirely covered. The surface is beautifully smooth and polished.

Locality, Pondicherry.

Genus Strombus, Linnæus.

1. *Strombus uncatus*, sp. nov. Pl. XIII. fig. 16.

S. testâ latè ovatâ, crassâ, anfractibus 6, convexiusculis; spirâ exsertâ, lævi: ultimo anfractu supernè regulariter flexuoso-sulcato; labro externo dilatato, latè aliformi, posticè incrassato, margine crassissimo, supernè sinuato, emarginato, infernè caudâ hamatâ; labro interno crassiusculo, spiram vix incrustante.

Length $1\frac{8}{12}$ inch. Breadth $1\frac{2}{12}$ inch. Length of body-whorl $1\frac{4}{12}$ inch.

Somewhat triangular in form in consequence of the peculiar shape of the wing-like outer lip, which is notched above and gradually curves to the canal, which suddenly turns forward in the form of a hook. The back of the lip is strongly thickened. The body-whorl is marked for its upper two-thirds with flexuous regular sulcations, ten to twelve in number. The spire is smooth and short, but prominent. The superior cleft claw of the lip does not rise as high as the suture of the body-whorl. The young shell is smooth and resembles a Buccinum. The cast is smooth and polished. It is distantly allied to the French Neocomian *Rostellaria alpinus*. To the next species it is intimately related. They are both abnormal forms of the genus *Strombus*.

Locality, Pondicherry, where it appears to be common.

2. *Strombus contortus*, G. B. Sowerby, MSS. Pl. XV. fig. 9.

S. testâ oblongâ, crassâ, spirâ exsertâ, anfractibus 6, superioribus costatis, ultimo semicos-

tato, costis longitudinalibus numerosis, subgibbosis, anticè lævi, labro externo margine crassissimo, lobato, lobo hamato, dorsaliter canaliculato, anticè contorto; labio interno incrassato, calloso, lævissimo, spiram incrustante; caudâ angustâ, hamatâ, intortâ.

Length $1\frac{3}{10}$ inch. Breadth 1 inch. Length of body-whorl 1 inch.

Nearly allied to the last species, but at the same time very distinct from it. The general form is somewhat triangular in consequence of the prolongation of the outer lip, which is bordered externally by a very thick margin which contracts centrally, where a single lobe projects in a hook-like form and appears pedunculated, since it widens out after leaving the body-whorl: the curve of the hook is upwards, and its apex reaches to about a line with the suture of the first volution. Beneath the hooked lobe the body-whorl very gradually narrows, and at the extremity is strongly curved inwards, forming a hooked canal. The upper half of the body-whorl is ornamented by strong ribs, gibbous in the centre and variable in number. The inner lip is callous, and incrusts the front of the spire. The whorls of the spire are all ribbed.

Locality, Trinchinopoly.

Genus Voluta, Linnæus.

1. *Voluta pyriformis*, sp. nov. Pl. XII. fig. 1.

V. testâ pyriformi, spirâ brevissimâ, anfractibus 5, lævigatis, supernè ad suturam obsoletè excavatis; aperturâ lanceolatâ, columellâ 4-plicatâ; plicis obliquis fortibus, æquidistantibus.

Length $4\frac{1}{4}$ inches. Breadth 2 inches. Height of spire $0\frac{4}{12}$ inch.

Although this shell appears smooth, it is really minutely striated by fine lines of growth: the lower part of the columella is quite smooth, slightly expanded, flattened and polished: the folds of the pillar-lip gradually disappear. From appearances presented by one of the specimens, it is probable that when alive the shell was marked by regular, rather distant, fine longitudinal lines of a light colour on a dark ground. No known cretaceous form of Volute approaches this species. It belongs to the same group with the tertiary *Voluta Lamberti*, though very distantly related to that species. The Cutch fossils described by Mr. Sowerby under the name of *Turbinellus bulbiformis* have some relations to this Volute.

Locality, Pondicherry.

2. *Voluta purpuriformis*, sp. nov. Pl. XII. fig. 2.

V. testâ ovatâ, spirâ brevi, anfractibus 7, superioribus convexiusculis, omnibus ad suturam læviter excavatis, sulcato-striis, striis in medio ultimi anfractûs obsoletis.

Length $2\frac{1}{2}$ inches. Breadth $1\frac{1}{2}$ inch. Height of spire $0\frac{8}{12}$ inch.

An ovate *Purpura*-like shell, with rounded whorls and a short spire. The surface of the body-whorl is furrowed at the lower part by deep regular spiral striæ,

which become rather suddenly obsolete in the centre, but are again strongly marked close to the suture, where all the whorls are slightly hollowed out. The plications of the columella are obscured by rock, but the shell is evidently a *Voluta* of the same group with that last described. Young specimens are not so ventricose as old ones.

Locality, Pondicherry.

3. *Voluta septemcostata*, sp. nov. Pl. XII. fig. 3.

V. testâ elongatâ, fusiformi, anfractibus scabris, convexiusculis, longitudinaliter 7-costatis, costis crassis rotundatis.

Length of the broken specimen $1\frac{1}{12}$ inch. (Probable entire length $1\frac{4}{12}$ inch.) Breadth (full) $0\frac{7}{24}$ inch. Length of second whorl $0\frac{5}{12}$ inch.

Shell lanceolate, whorls probably six or seven; under the lens the surface is rough through raised striæ of growth. The cast is smooth. The ribs become nearly obsolete at the suture, and are very tumid a little above the centre of each whorl.

The London clay *Voluta costata*, is related, but distantly, to this species. A species from the Craie chloritée of France, *Voluta Renauxiana*, is equally near it.

Locality, Pondicherry.

4. *Voluta muricata*, sp. nov. Pl. XII. fig. 4.

V. testâ ovatâ, spirâ brevi, anfractibus 5, ultimo supernè subangulato, longitudinaliter (14) costatâ, spiraliter sulcatâ, costis muricatis, plicis inferioribus frequentioribus; aperturâ lanceolatâ.

Length $0\frac{11}{12}$ inch. Breadth $0\frac{7}{12}$ inch. Height of spire $0\frac{5}{24}$ inch.

An ovate shell, barred by fourteen longitudinal ribs which are decussated and muricated by transverse ones, which are distant at the upper part of the body-whorl, where they leave nearly square interstices, but are much more frequent in the middle and very numerous towards the canal, where the longitudinal ribs become obsolete. The sutures are very slightly compressed. The plaits on the pillar-lip are not exposed.

The London clay *Voluta Lima*, comes very near this species, but is easily distinguished by the presence in the former of a canal winding round the summit of the whorls.

Locality, Pondicherry.

5. *Voluta Camdeo*, sp. nov. Pl. XII. fig. 5, *a*, *b*.

V. testâ ovato-oblongâ, spirâ exsertâ, anfractibus 6, planatis supernè subangulatis, prope suturam canaliculatis; longitudinaliter multiplicatis; ultimo infernè de medio spiraliter striato, suturis profundis.

Length $0\frac{4}{12}$ inch. Breadth $0\frac{5}{4}$ inch.

A very beautiful species. The whorls are all ribbed longitudinally; the ribs very numerous, rounded, and about as broad as the interspaces. The spire is of some length and turreted in consequence of the flatness of the whorls, which suddenly turn in towards the suture, the angle being furrowed by a deep and narrow canal. The sutures are deeply impressed. The lower half of the body-whorl is marked by regular, rather distant, well-defined spiral striæ.

Locality, Pondicherry.

6. *Voluta cincta*, sp. nov. Pl. XII. fig. 6.

V. testâ oblongâ, spirâ conicâ, anfractibus 6, supernè angulatis, longitudinaliter costatis, costis in angulis turgidis et prope suturam subobsoletis, spiraliter sulcatis, sulcis numerosis interstitiis striatis, marginibus internalibus crenulatis; aperturâ angulatâ, elongatâ, 4–5-plicatâ.

Length $1\frac{1}{4}$ inch. Breadth $0\frac{8}{12}$ inch. Spire $0\frac{1}{2}$ inch.

A more or less Cone-like shell, variable in form and sculpture, the number of longitudinal ribs and the strength of the spiral ones varying in almost every specimen. The former are usually about eighteen. One character is however constant; the summits of the whorls are angulated and more or less flattened. The flattened space is marked by spiral striæ only, and is bordered at the suture by a thickened crenulated rim.

The eocene *Voluta undosa* is related to this species, but differs in sculpture. No described cretaceous form approaches it.

Locality, Pondicherry; also at Trinchinopoly.

7. *Voluta breviplicata*, sp. nov. Pl. XII. fig. 7, *a*, *b*.

V. testâ ventricosâ, spirâ brevi, longitudinaliter plicatâ; anfractu ultimo inflato, supernè plicato, plicis numerosis, brevibus, evanescentibus, spiraliter striato, striis in medio distantibus, infernè approximatis; columellâ excavatâ; aperturâ oblongâ.

Length of last whorl 1 inch. Breadth $0\frac{9}{12}$ inch.

This volute, which is very distinct from all its companions, is easily recognised by its ventricose body-whorl, crimped at the upper part by numerous short plications, which are decussated near the suture by two deep sulcations, representing the canal seen in the last species. These sulcations are part of a series of spiral striæ which become very distinct in the central portion of the body-whorl, and are very numerous at its lower part. The pillar-lip is broad and expanded, and marked at its lowest portion by a shallow groove. The mouth, in the specimen examined, is obscured by rock.

Locality, Pondicherry.

8. *Voluta citharina*, sp. nov. Pl. XII. fig. 8, *a*, *b*.

V. testâ fusiformi, spirâ turritâ, anfractibus complanatis, supernè angulatis, longitudinaliter multiplicatis, spiraliter striatis: aperturâ lanceolatâ, columellâ 4-plicatâ.

Variat sulcis spiralibus supernè obsoletis.

Length 1 inch. Breadth $0\frac{1}{2}$ inch. Spire $0\frac{4}{12}$ inch.

A very elegant fusiform shell, with somewhat flattened volutions, angulated sharply near the suture, so as to give a turreted aspect to the spire. They are all barred by numerous longitudinal ribs nearly as broad as the interspaces, crossed by spiral striæ, which however do not muricate them, and are most numerous towards the canal. The sutures are impressed. The plaits upon the pillar-lip are strong, elevated and nearly equidistant. The cast is smooth and does not exhibit a trace of the angles of the whorls.

Locality, Pondicherry.

9. *Voluta radula*, G. Sowerby, MSS. Pl. XII. fig. 9.

V. testâ oblongâ, spirâ brevi, anfractibus 5, longitudinaliter (18–20) plicatis striatisque, spiraliter sulcatis; plicis nodulosis; suturâ profundâ; aperturâ lanceolatâ.

Variat plicis longitudinalibus obtusis, plus minusve distantibus.

Length $1\frac{2}{12}$ inch. Breadth $0\frac{8}{12}$ inch. Spire $0\frac{4}{12}$ inch.

A very variable shell, more or less ovate in consequence of variations in the length of the spire. All the whorls are longitudinally ribbed and spirally sulcated; the sulcations strongly marked, decussating and tuberculating the thick ribs. The first sulcus near the suture on the body-whorl is sometimes deeper than the others. The suture is deeply impressed.

It is a near ally of the tertiary *Voluta lima*.

Locality, Pondicherry, where it appears to be abundant.

10. *Voluta Trinchinopolitensis*, sp. nov. Pl. XV. fig. 5.

V. testâ oblongâ (spirâ brevi?), anfractu ultimo prope suturam angulato, supernè costatâ, costis (12) crassis, brevibus, distantibus (sulcis spiralibus nullis); aperturâ ——?

Probable length, when entire, $3\frac{1}{4}$ inches. Breadth $1\frac{3}{4}$ inch.

A fragment of a large and strong volute, very distinct from any of the other species in the collection. The body-whorl is ornamented at its upper part by strong, distinct, short, vanishing ribs: the lower half is smooth. The summits of the whorls are angled. Two of the plications of the body-lip are visible.

Locality, Trinchinopoly.

Genus Cypræa.

1. *Cypræa Kayei*, sp. nov. Pl. XII. fig. 20.

C. testâ globosâ, inflatâ, lævigatâ, spirâ exsertiusculâ, anfractibus 5.

Length $1\frac{3}{4}$ inch. Breadth $1\frac{7}{12}$ inch. Height $1\frac{1}{4}$ inch.

A very globular shell, with a smooth surface or faintly striated by lines of growth. The mouth is very narrow, widening a little below. The spire is slightly prominent and very regular: the whorls composing it are nearly flat. The cast is smooth.

Locality, Pondicherry.

2. *Cypræa Newboldi*, sp. nov. Pl. XII. fig. 21.

C. testâ ovatâ, lævi, in medio gibbosiusculâ, extremitatibus subcompressis, spirâ occultâ.
Length $1\frac{2}{10}$ inch. Breadth $0\frac{8}{10}$ inch. Height $0\frac{6}{10}$ inch.

Ovate, swelling out centrally, compressed and slightly attenuated at the extremities. Mouth widening a little below, very narrow in the centre. Outer lip gibbous centrally. Denticulations of both lips rather deeply placed. Surface smooth.

Locality, Pondicherry.

3. *Cypræa Cunliffei*, sp. nov. Pl. XII. fig. 22.

C. testâ ovatâ, minutissime transversè striatâ; spirâ occultâ.
Length $0\frac{8}{10}$ inch. Breadth $0\frac{5}{10}$ inch. Height $0\frac{4}{10}$ inch.

A very elegant, regularly ovate shell; the lower extremity is very slightly produced. The surface is marked by very fine regular transverse striæ. The mouth is narrow and of nearly equal dimensions throughout. The spire is hidden.

Locality, Pondicherry.

Genus Oliva, Bruguière.

1. *Oliva vetusta*, sp. nov. Pl. XII. fig. 23, *a*, *b*.

O. testâ elongatâ, lanceolatâ, lævi, nitidâ, spirâ productâ, columellâ expansâ.
Length $0\frac{4}{10}$ inch. Breadth $0\frac{2}{10}$ inch.

A smooth polished shell with a produced spire of three or four slightly convex whorls. The columella is expanded, and the body-lip reflected broadly over the canal and marked by four obsolete sulcations.

This is the first species of its genus found associated with cretaceous forms.

Locality, Pondicherry.

Genus Eulima, Risso.

1. *Eulima antiqua*, sp. nov. Pl. XII. fig. 17.

E. testâ lævissimâ, turriculatâ, anfractibus 9, planatis, superioribus latis, striis duabus obsoletis ad suturam cinctis.
Length $0\frac{1}{2}$ inch. Maximum breadth of body-whorl $0\frac{3}{20}$ inch.

Shell very smooth, but impressed near the shallow suture of the nearly flat whorls with two obscure striæ; body-whorl ovate, whorls of spire rather broad and very gradually diminishing. Though the mouth is broken this fossil is evidently an *Eulima*, and approaches nearly some existing species.

Locality, Pondicherry.

Genus Tornatella, Lamarck.

1. *Tornatella labiosa*, sp. nov. Pl. XII. fig. 24.

T. testâ ovato-oblongâ, spirâ exsertâ, anfractibus convexiusculis (ultimo subinflato), spiraliter sulcatis, sulcis numerosis, longitudinaliter striatis, interstitiis lævibus; aperturâ lato-lanceolatâ, labro interno calloso, externo subincrassato, striato.

Length $0\frac{11}{25}$ inch. Breadth $0\frac{11}{25}$ inch.

Shell ovate, the whorls rather flattened, yet the last swelling out at its lower part so as to appear inflated. The spire is prominent and formed of five or six whorls. All the whorls are deeply sulcated spirally. The sulcations are strongly striated longitudinally. The interspaces are smooth and as broad as the furrows. The mouth is lanceolate, broad below and somewhat lunate. The pillar-lip is callous above and partially striated. The cast is smooth.

Locality, Pondicherry.

2. *Tornatella curculio*, sp. nov. Pl. XII. fig. 25.

T. testâ cylindricâ, spirâ brevi, anfractibus 6, planatis, spiraliter sulcatis, sulcis numerosis, longitudinaliter striatis, interstitiis angustioribus; suturis profundis; aperturâ?

Length $0\frac{8}{10}$ inch. Breadth $0\frac{1}{2}$ inch.

A cylindrical shell, the whorls very flat, suddenly bending in to the deep suture, all deeply striated or sulcated spirally, the sulcations marked by numerous fine longitudinal striæ, which do not cross the somewhat broader interspaces. None of our specimens show the mouth.

Locality, Pondicherry.

3. *Tornatella semen*, sp. nov. Pl. XV. fig. 2, *a*, *b*, *c*.

T. testâ ovatâ, tumidâ, politâ, spirâ prominenti, acutâ, anfractibus 5, convexis, spiraliter punctato-striatis, striis longitudinalibus distantibus leviter decussatis; columellâ contortâ, biplicatâ.

Length $0\frac{3}{10}$ inch. Breadth $0\frac{2}{10}$ inch.

Shell ovate, with a prominent but rapidly decreasing spire. The surface is finely striated spirally, the striations punctate. At first glance it seems smooth and polished. The body-whorl is very tumid. The mouth is concealed by rock in the only perfect specimen in the collection; but there is a fragment which shows a contorted pillar-lip with two strong folds, the uppermost largest.

Locality, Trinchinopoly.

Genus Ringicula, Deshayes.

1. *Ringicula? acuta*, sp. nov. Pl. XV. fig. 3.

R. testâ oblongâ, lævi, spirâ prominenti, acutâ, anfractibus 5, superioribus planatis, ultimo infernè tumido, labio externo incrassato.

Length $0\frac{2}{10}$ inch. Breadth rather more than $0\frac{1}{10}$ inch.

A little smooth shell, with a conical and acute spire, the whorls of which are separated by a rather deep suture. The body-whorl is rather flattened at the upper part, tumid below, and is obscurely marked by lines of growth. The outer lip is thickened. The mouth is concealed by rock, but the general aspect of the shell is that of a *Ringicula*.

Locality, Trinchinopoly.

Genus Natica, Lamarck.

1. *Natica pagoda*, sp. nov. Pl. XII. fig. 14.

N. testâ elongato-conicâ, vix umbilicatâ, lævigatâ, striis longitudinalibus minutis, spirâ turritâ, anfractibus 6, ad suturam planatis sulcatisque, superioribus convexiusculis, ultimo rotundato, aperturâ ovato-lanceolatâ.

Length $1\frac{1}{2}$ inch. Breadth $0\frac{9}{12}$ inch. Spire $0\frac{4}{12}$ inch.

This species has a very large and rounded body-whorl; and a much-produced, turreted acute spire. The whorls are deeply channeled, though narrowly, along the line of suture, and are flattened or slightly angled for some distance beyond. The surface is to the eye smooth, but when examined with a lens shows minute and regular striæ of growth. The umbilicus is either very small or almost obsolete.

It is nearly allied to the lower greensand *Natica rotundata*, but is much more produced in the spire.

Locality, Pondicherry.

2. *Natica obliquistriata*, sp. nov. Pl. XII. fig. 12.

N. testâ subglobosâ, subumbilicatâ, anfractibus convexis, sub lente obliquè striatis, supra planis, suturis excavatis, decussato-striatis, aperturâ oblongâ.

Length 1 inch. Breadth $0\frac{8}{10}$ inch.

Smooth and polished at first glance, but on closer observation seen to be marked with fine oblique undulating striæ. On the summits of the whorls at the line of suture there is a broad shallow impression which is striated by four or five deep spiral striæ, decussated by lines of growth. The shell is thick. The cast is smooth.

Locality, Pondicherry.

3. *Natica suturalis*, G. Sowerby, MSS. Pl. XV. fig. 1.

N. testâ subglobosâ, spirâ brevi, obtusâ; anfractibus 5 lævigatis, supernè subangulatis, prope suturam canaliculatis; ad suturam marginatis; umbilico angusto.
Length $0\frac{6}{10}$ inch. Breadth $0\frac{5}{10}$ inch.

Shell globose, smooth, in very young specimens spirally striated. The whorls are depressed near the suture and channeled. The canal is traversed by regular lines of growth, and is separated from the suture by a raised margin. The spire is obtuse. The mouth is rather wide. The pillar-lip is grooved by a deep and defined but narrow umbilicus, which is bounded externally by a shallow groove.
Locality, Trinchinopoly.

4. *Natica*? *rugosissima*, sp. nov. Pl. XIV. fig. 7.

N. testâ subglobosâ, spirâ parvâ, depressâ, anfractibus 4 transversè rugosis, sulcis profundis irregularibusque ornatis; umbilico?
Breadth $0\frac{7}{12}$ inch. Height $0\frac{4}{12}$ inch.

A remarkable shell, easily distinguished by its very low spire and the deep sulcations or rather plications which ornament the whorls.
Locality, Verdachellum.

Genus Calyptræa, Lamarck.

1. *Calyptræa*? *elevata*, sp. nov. Pl. XII. fig. 10, *a*, *b*.

C. testâ conicâ, lævi, expansâ, apice obtuso, centrali.
Breadth $1\frac{2}{12}$ inch. Height $0\frac{7}{12}$ inch.

A large and very convex yet very broad shell; it appears to have been smooth or very slightly undulated concentrically. The apex is obtuse and central. Though the internal structure of this shell is unknown, there can be little doubt of the propriety of referring it to the genus *Calyptræa*.
Locality, Pondicherry.

2. *Calyptræa*? *corrugata*, sp. nov. Pl. XII. fig. 11, *a*, *b*.

C. testâ valdè conicâ, inflatâ, concentricè corrugatâ, longitudinaliter obsoletè striatâ, apice excentrico, contorto.
Breadth $0\frac{7}{10}$ inch. Height $0\frac{5}{10}$ inch.

Shell very tumid, regularly wrinkled concentrically, and somewhat obscurely marked with longitudinal striæ. The apex is very much out of the centre and turned down, though rather obtuse. I place this shell provisionally in *Calyptræa*, but it may prove to be a form of *Pileopsis*, or some allied shell. It is next to im-

possible, at present, to determine with certainty the genus of a fossil *patelliform* shell, or even the family of which it is a member.

Locality, Pondicherry.

Genus Dentalium, Linnæus.

1. *Dentalium arcotinum*, sp. nov. Pl. XII. fig. 16.

D. testâ subulatâ, tereti, subarcuatâ, lævi, sub lente striis concentricis minutissimis ornatâ.
Length $1\frac{7}{12}$ inch. Breadth at mouth $0\frac{2}{12}$ inch.

A very slightly bent shell, bearing a considerable resemblance to the recent *Dentalium entalis*, to which indeed it approaches more nearly than to any known secondary forms. The surface when magnified is seen to be marked by very minute concentric striæ.

Locality, Pondicherry.

2. *Dentalium*? *hamatum*, sp. nov. Pl. XV. fig. 8.

D. testâ cylindricâ, concentricè striatâ, extremitate posteriori arcuatissimâ.
Length, exclusive of the hook, $1\frac{1}{10}$ inch. Breadth at the mouth nearly $0\frac{2}{10}$ inch.

This shell, which is shaped singularly like a fish-hook, is possibly not that of a mollusk, but the calcareous case of an annelide. Yet as all the known species of *Ditrupa*, the genus of tubicular annelides, with which a *Dentalium* may be confounded, have contracted mouths, whilst all living *Dentalia* have the greatest diameter of the shell at the aperture, I prefer provisionally placing it in the latter genus.

Locality, Trinchinopoly. It appears to have been gregarious.

Acephala Palliobranchiata.

Genus Terebratula, Bruguière.

1. *Terebratula arabilis*, sp. nov. Pl. XVIII. fig. 12.

T. testâ orbiculari, subdepressâ, concentricè sulcatâ, sulcis numerosis, profundiusculis; margine frontali obsoletè bisinuato, foramine magno.
Length $1\frac{4}{12}$ inch. Breadth $1\frac{2}{12}$ inch. Thickness $0\frac{7}{12}$ inch.

A very broad or rather orbicular species, depressed, the ventral valve especially. Both valves are ploughed, as it were, by shallow, regular concentric furrows. The surface is minutely punctate. The frontal margin in full-grown shells becomes slightly bisinuated. The beak of the ventral valves is truncated so as to present a large foramen. In process of growth the shell widens, young specimens being much longer than wide, old ones as broad as long.

The *Terebratula albensis* of Leymerie, from the chalk of France, closely resembles this species in form, but has not the concentric sulcations.

Locality, Pondicherry.

2. In the Verdachellum collection there is a fragment of a plicated *Terebratula* evidently nearly allied to some greensand species.

Acephala Lamellibranchiata.

Genus Clavagella, Lamarck.

1. *Clavagella semisulcata*, sp. nov. Pl. XVII. fig. 1.

C. valvulis ovatis, depressis, inæquilateralibus, prope umbones obsoletè sulcatis striatisque. Tubo recto, extremitate conchiferâ magnâ, clavatâ, tuberculatâ.

Breadth of a valve $0\frac{3}{4}$ inch. Length $0\frac{1}{2}$ inch.

Valves large, ovate, with the beaks near one end, ends rounded; one half the surface, that nearest the beaks, marked with transverse furrows and striæ. The surface of the investing tube is rugose and tuberculated in front of the shell. The tube is cylindrical, smooth, and very much smaller than its clavate extremity.

The *Clavagella cretacea* of M. D'Orbigny is its nearest ally.

Locality, Pondicherry.

Genus Fistulana, Bruguière.

1. *Fistulana? aspergilloides*, sp. nov. Pl. XVII. fig. 2.

F. tubo tereti, longo, cylindrico, concentricè subsulcato, extremitate abruptè truncatâ, convexiusculâ.

Length $3\frac{1}{2}$ inches. Breadth at base $0\frac{3}{10}$ inch.

This fossil approaches so nearly in aspect to a living *Fistulana* of the Indian seas, that I can scarcely doubt its relations to that genus.

Locality, Pondicherry.

Genus Panopæa, Menard.

1. *Panopæa orientalis*, sp. nov. Pl. XVII. fig. 4.

P. testâ transversè oblongâ, valdè inæquilaterali, concentricè regulariter undulato-sulcatâ, extremitatibus rotundatis, hiantibus.

Length $1\frac{10}{12}$ inch. Breadth 3 inches. Length from beak to farthest extremity $2\frac{1}{2}$ inches.

Shell very inequilateral, yet equally rounded at both ends, gaping at the extremities; the surface marked with regular distant furrows. It belongs to a group of *Panopæa* very difficult to define specifically, ranging through many strata, probably from the palæozoic rocks upwards into the tertiaries, but chiefly concentrated and most numerous in the lower cretaceous beds. *Panopæa plicata* and some other lower greensand species are nearly allied to this Indian form, which however I cannot satisfactorily unite with any of them.

Locality, Pondicherry (and Verdachellum).

Genus Pholadomya, Sowerby.

1. *Pholadomya connectans*, sp. nov. Pl. XVII. fig. 5.

P. testâ transversè ovatâ, inæquilaterali, extremitatibus rotundatis (subhiantibus) concentricè sulcatâ, in medio longitudinaliter decemcostatâ, costis radiantibus.

Length $0\frac{11}{12}$ inch. Breadth $1\frac{7}{12}$ inch. Thickness $0\frac{9}{12}$ inch. Length from beak to farthest extremity $1\frac{4}{12}$ inch.

A well-marked and handsome species, most nearly allied to the *Pholadomya ovalis* of the upper oolite, and to the *P. parvula* of the oolite of Hanover. It connects such forms with *Pholadomya Martini* of the lower greensand.

Locality, Pondicherry.

Genus Poromya, Forbes.

Char. Gen. Testa plus minusve globulosa, æquivalvis, posticè paululùm producta, tenuis, punctata. *Cardo* in valvulâ dextrâ dente cardinali valido, *laterali nullo*; in valvulâ sinistrâ dente cardinali obsoleto, foveâ ligamentali oblongâ. *Umbones* anticè retorti. *Impressiones musculares* duæ. *Sinus palliaris* parvus.

The position of this very natural and well-marked genus, indicated in my Report on the Invertebrata of the Ægean, is between *Corbula* and *Neæra*; and when the animal shall have been examined, it will most probably be found closely resembling that of the last-named genus. The existing species of *Poromya* are two; one, nearly allied to the first of the fossil forms here described, inhabits the Chinese seas, and was described by Mr. Hinds under Mr. Sowerby's name of *Neæra hyalina*. I have examined the specimens of this beautiful shell in Mr. Cuming's unrivalled collection. The second *Poromya anatinoides* was found by myself in the eastern Mediterranean, where it lives only in very great depths. It is not so near the Indian fossil species as the first, but is very closely allied, indeed possibly identical, with a species found fossil in the English and Belgian crags, and described

by M. Nyst under the name of *Corbula granulata*. The *Corbula æquivalvis* of Goldfuss, a fossil from the greensand of Westphalia, also belongs to this genus and is nearly allied to the Pondicherry species.

1. *Poromya globulosa*, sp. nov. Pl. XVII. fig. 6.

P. testâ inflatâ, suborbiculari, subinæquilaterali, anticè subsinuatâ, politâ, lævigatâ, sub lente punctis minutissimis numerosis in seriebus obliquis dispositis ornatâ; umbonibus tumidis, incurvatis.

Length $0\frac{7}{10}$ inch. Breadth $0\frac{3}{4}$ inch. Thickness of united valves $0\frac{1}{2}$ inch.

Shell much-inflated, almost globular, but slightly produced and compressed at one extremity. The surface appears smooth and polished to the naked eye, but is really, as may be seen by using the lens, minutely and regularly punctate, the punctations numerous and arranged in oblique lines. This character is lost when the shell is worn, as the punctations do not perforate it. The beaks are turned towards the shorter end, and there is an appearance of a cordate lunule.

Locality, Pondicherry.

2. *Poromya lata*, sp. nov. Pl. XV. fig. 14.

P. testâ tenui, latâ, convexâ, lævi, (sub lente radiato-punctatâ, punctis distantibus,) subinæquilaterali, extremitatibus rotundatis, postico subrostrato.

Length $0\frac{8}{10}$ inch. Breadth 1 inch.

An oblong very thin shell, slightly produced at one end and there somewhat depressed. The surface is smooth to the eye, but under the lens is seen to be marked by regular radiating lines of distant granuliferous punctations.

Locality, Trinchinopoly.

Genus Corbula, Bruguière.

1. *Corbula striatuloides*, sp. nov. Pl. XVIII. fig. 14.

C. testâ ovatâ, subcompressâ, incrassatâ, sulcato-striatâ, rostratâ, rostro carinatâ.

Length $0\frac{3}{12}$ inch.

A small, ovate, thick, transversely-furrowed shell with a more or less carinated beak. It is nearly allied to the British lower greensand *Corbula striatula*, but is more compressed.

Locality, Verdachellum.

Genus Solecurtus, De Blainville.

1. *Solecurtus obscurus*, sp. nov. Pl. XVII. fig. 3.

S. testâ transversè striatâ, valdè inæquilaterali, elongatâ, compressâ, extremitatibus rotundatis, *umbonibus obtusissimis.*

Length from end to end $2\frac{2}{12}$ inches; from beak to frontal margin $0\frac{7}{12}$ inch; from beak to farthest extremity $1\frac{7}{12}$ inch. Thickness of united valves $0\frac{7}{24}$ inch.

A cast, with a portion of the shell attached showing the striated surface. The cast is obsoletely sulcated across. The hinge-line is margined and somewhat compressed.

Locality, Pondicherry.

Genus Tellina, Linnæus.

1. *Tellina? pondicherriensis.*, sp. nov. Pl. XVIII. fig. 15.

T.? testâ transversè striatâ, ovato-elongatâ, valdè inæquilaterali, extremitatibus rotundatis, umbonibus acutis.

Measurement from end to end $0\frac{7}{12}$ inch. From beak to frontal margin $0\frac{5}{12}$ inch. Thickness of united valves $0\frac{2}{12}$ inch.

The frontal margin is nearly straight. The cast is smooth.

Locality, Pondicherry.

Genus Psammobia, Lamarck.

1. *Psammobia? inconspicua*, G. B. Sowerby, MSS. Pl. XV. fig. 18.

P. testâ transversè oblongâ, latâ, depressâ, lævi seu substriatâ, subinæquilaterali, margine dorsali arcuato.

Length $0\frac{8}{10}$ inch. Breadth $1\frac{5}{10}$ inch.

A single valve, not in very good condition, but very distinct from any other shell in the collection, and most probably a species of *Psammobia*.

Locality, Trinchinopoly.

Genus Mactra, Lamarck.

1. *Mactra tripartita*, G. B. Sowerby, MSS. Pl. XV. fig. 17.

M. testâ transversè oblongâ, subtriangulari, depressiusculâ, subæquilaterali, concentricè sulcatâ, sulcis numerosis confertis, regularibus, lateribus truncatis, apice acuto.

Breadth 1 inch. Length $0\frac{8}{10}$ inch. Height $0\frac{2}{10}$ inch.

The only species of its genus in the collection. The surface is beautifully grooved by numerous regular close transverse striations, which suddenly become much stronger on the truncated sides. The cast is smooth.

Locality, Trinchinopoly.

Genus Lucina, Bruguière.

1. *Lucina jugosa*, sp. nov. Pl. XVII. fig. 7.

L. testâ orbiculari, depressâ, concentricè regulariter sulcatâ, sulcis numerosis (50), margine cardinali acutâ.

Length $1\frac{5}{24}$ inch. Breadth $1\frac{2}{12}$ inch. Thickness $0\frac{1}{2}$ inch.

A shell in form much resembling an *Artemis*, orbicular, depressed, and ornamented with numerous regular concentric striæ. Its nearest relative is perhaps the Grignon fossil named by Lamarck *Lucina concentrica*.

Locality, Pondicherry.

2. *Lucina fallax*, sp. nov. Pl. XVII. fig. 8.

L. testâ orbiculari, compressâ, latere antico obsoletè sinuato, concentricè sulcatâ striatâque, striis longitudinalibus minutissimis ornatâ.

Length and breadth nearly 1 inch.

The cast of this shell is smooth and polished, but exhibits traces of minute longitudinal striæ, regular but obsolete. The muscular impressions are long and very strongly marked.

Locality, Pondicherry.

Genus Anatina, Lamarck.

1. *Anatina arcuata*, sp. nov. Pl. XVI. fig. 5.

A. testâ inæquilaterali, transversè lanceolatâ, arcuatâ, compressâ, anticè subangulatâ, rotundatâ, dilatatâ; posticè longè rostratâ, rostro truncato, bicarinato, carinis obtusis; transversè sulcatâ striatâque, sulcis concentricis regularibus subdistantibus, in carinam non productis.

Length opposite beak $1\frac{1}{4}$ inch. Breadth $5\frac{1}{2}$ inches. Greatest breadth of wide end $1\frac{1}{2}$ inch. Thickness of united valves $0\frac{8}{12}$ inch. Length of beak $2\frac{8}{12}$ inches. Its breadth at the extremity $0\frac{6}{12}$ inch.

A much-compressed, bent, elegantly sulcated shell, with one extremity broad and rounded, except towards the cardinal margin, where it is slightly angulated; the other tapering to a narrow beak truncated at the extremity and bearing two obtuse keels on its surface. The marks of the hinge-appendages cause a deep curved linear impression on each valve, proceeding from the beaks. The cardinal margin is rather straight. In young specimens the beaks are more tumid and the shell much shorter in proportion.

This elegant species is nearly allied to the *Anatina Robinaldina* described by M. D'Orbigny from the Neocomian beds of France.

Locality, Pondicherry.

Genus Astarte, Sowerby.

1. *Astarte planissima*, sp. nov. Pl. XV. fig. 23.

A. testâ suborbiculari, valdè compressâ, concentricè sulcatâ striatâque, sulcis distantibus, regularibus, interstitiis declivis, ad marginem dorsalem subspinosis.

Length $0\frac{6}{10}$ inch. Breadth $0\frac{6}{10}$ inch.

Shell slightly quadrate in outline, very much depressed, ornamented with concentric striæ, filling up regular deep distant concentric furrows. Ten or eleven large

sulcations are seen on the surface of a shell of the above dimensions. In the interior the presence of these sulcations is indicated only on the upper half of the shell. The ribs which separate them are sloping, and rise into tubercles or short spines where they terminate at the margin. This character approaches so nearly that seen in the existing *Lucina spinifera*, that I have some doubts, in the absence of the hinge, of the shell being a true *Astarte*. The pallial impression is entire, and the muscular impressions are very strong.

Locality, Trinchinopoly.

Genus Cardita, Bruguière.

1. *Cardita orbicularis*, sp. nov. Pl. XVII. fig. 11.

C. testâ orbiculari, convexâ, costis longitudinalibus (22) rotundatis (squamosis?).
Length $0\frac{13}{25}$ inch. Breadth $0\frac{1}{2}$ inch.

A single specimen in bad condition, but evidently a very distinct species. Its nearest known allies are tertiary forms, but the genus extends throughout the Cretaceous system.

Locality, Pondicherry.

2. *Cardita striata*, sp. nov. Pl. XIV. fig. 1.

C. testâ suborbiculari, subdepressâ, longitudinaliter costatâ striatâque, costis (30) 4-striatis.
Length $0\frac{11}{12}$ inch. Breadth the same.

A very distinct species remarkable for its sculpture, the surface being ornamented with thirty or more radiating ribs, each of which is marked by about four longitudinal striæ.

Locality, Verdachellum.

Genus Cardium, Linnæus.

1. *Cardium bisectum*, sp. nov. Pl. XVII. fig. 9.

C. testâ elongatâ, angustè oblongâ, inflatâ, lateribus subcompressis, concentricè striis minutis ornatâ, dimidio longitudinaliter striato-sulcatâ, sulcis subcentralibus (10) majoribus; umbonibus prominentibus incurvatis.
Length $2\frac{1}{2}$ inches. Breadth $1\frac{3}{4}$ inch. Thickness $2\frac{1}{12}$ inches.

Remarkable for its elongated, tumid and compressed form, and singular division of the shell into two parts, the one longitudinally sulcated, the other almost smooth. Consequently one-half of the margin only is crenulated. The cast is smooth and shining. *Cardium impressum*, a Neocomian species described by Deshayes, is distantly related to this form.

Locality, Pondicherry.

2. *Cardium lucerna*, sp. nov. Pl. XVII. fig. 10.

C. testâ transversè oblongâ, subinflatâ, subinæquilaterali, longitudinaliter crebrisulcatâ, costis quadratis (28) obsoletè squamosis, latere postico lævi, antico rostrato, rostro brevi, compresso, lævi; umbonibus tumidis, concentricè substriatis.

Length 1 inch. Breadth $1\frac{1}{4}$ inch. Thickness of united valves $0\frac{10}{12}$ inch.

An elegant lamp-shaped shell, ornamented with longitudinal ribs, and having one extremity prolonged into a smooth and compressed beak. In form it resembles the living *Cardium Cumingii* described by Broderip. Its nearest ally is probably the *Cardium subdinense*, a species described by M. D'Orbigny from the Craie chloritée of France.

3. *Cardium incomptum*, G. B. Sowerby, MSS. Pl. XV. fig. 16.

C. testâ convexâ, obliquè suborbiculari, radiatim costatâ, costis (20–22) prominentibus subsquamosis.

Length $0\frac{3}{10}$ inch. Breadth $0\frac{3}{10}$ inch. Height of a valve $0\frac{2}{10}$ inch.

A Cockle of the same group with *Cardium edule*. The shell is tumid, more or less obliquely round, and ornamented with radiating ribs, which are prominent and separated by deep sulcations.

Locality, Trinchinopoly.

4. *Cardium intersectum*, sp. nov. Pl. XVIII. fig. 8.

C. testâ convexâ, suborbiculari, subdepressâ, subangulatâ, concentricè sulcatâ, striis ad angulum posticum costâ radiali obscurâ lævi interruptis, sulcis post radium fortioribus.

Length $0\frac{6}{10}$ inch. Breadth $0\frac{1}{2}$ inch.

A somewhat depressed species remarkable for its peculiar sculpture. From the beak to the angle of the siphonal side there runs a smooth, gradually enlarging ray or obsolete rib, which interrupts the concentric striæ of the remainder of the shell, or rather separates the deep concentric striæ of the anteal and central portions from the deep transverse sulci in the space above the siphonal margin.

There is only a single imperfect specimen of this very distinct species in the collection. It is from Verdachellum.

5. *Cardium altum*, G. B. Sowerby, MSS. Pl. XV. fig. 13.

C. testâ oblongâ, tumidâ, posticè subtruncatâ, angulatâ, longitudinaliter substriatâ, anticè lævigatâ, in medio concentricè sulcato, sulcis regularibus, interstitiis æquantibus.

Testâ decorticatâ reticulato-striatâ.

Testâ juniori subquadratâ, acutè angulatâ.

Length $1\frac{7}{10}$ inch. Breadth $1\frac{4}{10}$ inch. Height $0\frac{6}{10}$ inch.

The differences presented by this shell at different periods of its growth and in various states of preservation are very remarkable, and, unless noted, sure to mislead. When young (fig. 15) it is a nearly smooth shell, of a more or less suborbicular or quadrate form, strongly and angularly truncate at the siphonal side, and there marked by longitudinal striæ. When full-grown it becomes ovate, the angulation gradually disappears, the siphonal side is marked by obscure striæ which suddenly cease at the angle, the opposite side is quite smooth, and the interspace is marked by close, regular, numerous concentric sulcations. But whether old or young, if it be decorticated, the markings of the surface become altogether different; the siphonal truncated portion becomes deeply punctato-striate, and the whole of the remainder of the shell is finely decussated.

This *Cardium* belongs to the same group with *Cardium subhillanum*, *C. sphæroideum*, *C. concentricum*, and other cretaceous forms. It is very near to the last-named species, from the greensand of Halden.

Locality, Trinchinopoly.

6. *Cardium Hillanum*, Sowerby.

I have not thought it necessary to figure this species, as the specimens agree in every essential character with British examples from Blackdown. The transverse sulcations are rather coarser than in ordinary varieties, but after comparing the Indian species with a considerable suite of the European, I could not draw any line between them, since varieties exactly corresponding occurred among the latter.

Locality, Verdachellum and Trinchinopoly.

Genus Isocardia, Lamarck.

1. *Isocardia subsinuata*, sp. nov. Pl. XVII. fig. 12.

I. testâ suborbiculari, inflatâ, concentricè regulariter sulcatâ, latere antico obsoletè tri-sinuato, umbonibus prominentibus, distantibus, incurvatis.

Length $0\frac{3}{4}$ inch. Breadth $0\frac{8}{12}$ inch. Thickness $0\frac{10}{12}$ inch.

This very beautiful and well-marked *Isocardia* needs no further description than that given in the diagnosis. It is very distinct from any species with which I am acquainted.

Locality, Pondicherry.

Genus Venus, Linnæus.

1. *Venus arcotensis*, sp. nov. Pl. XV. fig. 19.

V. testâ orbiculari, subobliquâ, inæquilaterali, plus minusve convexâ, politâ, concentricè striatâ, striis confertis, irregularibus, margine lævi, umbonibus prominentibus, lunulâ minutâ.

Length $1\frac{3}{10}$ inch. Breadth $1\frac{4}{10}$ inch. Height of a valve $0\frac{3}{10}$ inch.

This shell varies in degree of convexity. It approaches certain species of *Artemis* in outline. Mr. G. B. Sowerby regarded it as a variety of the *Cytherea semisulcata* of Lamarck, a fossil of the Paris basin. There are sufficient differences however to lead us to infer that were colour present—a character so important in this genus that very similar fossil forms from different beds can never be identified with certainty—we should find the Indian very different from the French species.

Locality, Trinchinopoly.

2. *Venus analoga*, sp. nov. Pl. XV. fig. 20.

V. testâ transversè oblongâ, depressâ, inæquilaterali, lævi seu substriatâ, margine lævi, umbonibus obtusis, lunulâ —— (occultâ).

Length $0\frac{5}{10}$ inch. Breadth $0\frac{8}{10}$ inch. Height of a valve $0\frac{2}{10}$ inch.

An ovate, depressed, smooth and polished species gracefully rounded at the extremities. The surface is marked by obsolete striæ of growth. Compared by Mr. G. B. Sowerby with the *Cytherea nitidula* of Deshayes, an eocene fossil.

Locality, Trinchinopoly.

3. *Venus eximia*, sp. nov. Pl. XV. fig. 21.

V. testâ transversè ovatâ, subæquilaterali, depressâ, politâ, concentricè regulariter sulcato-striatâ, marginibus lævibus, umbonibus prominentibus, parvis, lunulâ oblongâ.

Length $0\frac{8}{10}$ inch. Breadth 1 inch. Height of a valve $0\frac{2}{10}$ inch.

A much-depressed oblong shell, beautifully marked by deep, close and regular concentric striations. The anteal cardinal margin slopes suddenly and obliquely, so as in young specimens to give an angular appearance to the outline; the beaks are small but very prominent. Considered by Mr. G. B. Sowerby identical with the eocene *Cytherea elegans* of Lamarck. There are however sufficient distinctions to keep them apart, independent of the improbability of their being identical.

Locality, Trinchinopoly.

Genus Artemis, Poli.

1. *Artemis lenticularis*, sp. nov. Pl. XVIII. fig. 7.

A. testâ orbiculari, depressâ, concentricè regulariter striatâ, margine vaginali arcuato-obliquâ.

Length and breadth $0\frac{11}{12}$ inch.

The above characters are scarcely sufficient to separate this species from an existing *Artemis* of the European seas, *Artemis lincta*, yet we can scarcely doubt that they are very distinct from each other. The curve of the vagino-cardinal margin is different, and this character in the genus *Artemis* usually accompanies others of importance. Most probably the colour of the species when alive—a

most important source of character among the *Veneridæ*—was well-marked and characteristic. A greensand shell from Germany, the "*Lucina lenticularis*" of Goldfuss, is very similar in outline to the Indian fossil.

Locality, Verdachellum.

Genus Nucula, Lamarck.

1. A single species of this genus, as now restricted, is contained in the Pondicherry collection. It is a smooth, polished, transversely ovate shell, very inequilateral, angulated behind and rounded before; the margins are smooth; these characters would almost apply to many *Nuculæ*, recent and fossil, for the variations of form in this genus have been as slight and unsatisfactory in time as they are now in space. It may provisionally be named *Nucula indefinita*; though difficult to define, I have little doubt that when well-preserved specimens shall have been procured it will prove very distinct.

Genus Leda, Schumacher.

1. *Leda striatula*, sp. nov. Pl. XVII. fig. 14.

L. testâ transversè oblongâ, compressâ, subæquilaterali, striis subobliquis ornatâ, posticè latè sed brevirostratâ, subangulatâ, anticè rotundatâ.

Length $0\frac{7}{12}$ inch. Breadth $0\frac{4}{12}$ inch. Thickness of united valves $0\frac{2}{12}$ inch.

A very distinct and well-marked species, remarkable for its compression, broad beak, and surface ornamented with very fine, numerous oblique striæ. It is allied most nearly to the *Nucula scapha* of D'Orbigny, a lower greensand species found in both France and England.

Locality, Pondicherry.

Genus Arca, Linnæus.

1. *Arca japetica*, sp. nov. Pl. XVI. fig. 2.

A. testâ inflatâ, carinatâ, transversè ovatâ, anticè obliquè truncatâ, posticè angustatâ, lateribus striatis, in medio sulcato-striatâ, margine frontali recto; areâ cardinali latâ, umbonibus prominentibus distantibus.

Extreme length $2\frac{1}{2}$ inches. Extreme breadth $2\frac{3}{4}$ inches. Thickness $2\frac{1}{12}$ inches. Distance between beaks $0\frac{7}{12}$ inch. Area $1\frac{10}{12}$ inch.

A strong, inflated, carinated, longitudinally sulcated species with an extensive cardinal area. It is allied to the *Arca exaltata* of Nilsson, a lower greensand species.

Locality, Pondicherry.

2. *Arca Gamana*, sp. nov. Pl. XVI. fig. 3.

A. testâ inflatâ, carinatâ, transversè subquadratâ, lævigatâ, anticè obliquè truncatâ, angulatâ,

posticè rotundatâ, margine frontali subtruncato; areâ cardinali lanceolatâ, umbonibus prominentibus.

Length $0\frac{10}{12}$ inch. Breadth $0\frac{14}{12}$ inch. Thickness $0\frac{10}{12}$ inch. Distance between beaks $0\frac{5}{23}$ inch. Breadth of area $0\frac{9}{28}$ inch.

A smooth moderately-inflated form with a lanceolate cardinal area. It is nearly allied to the *Arca ligeriensis* of D'Orbigny, a French Craie chloritée species.

Locality, Pondicherry.

3. *Arca brahminica*, sp. nov. Pl. XVI. fig. 1.

A. testâ subinflatâ, obsoletè carinatâ, transversim subquadratâ, lævigatâ, anticè obliquè subtruncatâ, posticè rotundatâ, margine frontali rotundato, areâ cardinali angustissimâ, umbonibus approximatis.

Length $2\frac{1}{4}$ inches. Breadth 3 inches. Thickness (valves united) 2 inches. Distance between beaks $0\frac{3}{24}$ inch. Breadth of area $0\frac{3}{4}$ inch.

The small area, as compared with the size of the shell, and the peculiar outline sufficiently distinguish this Ark. The surface bears traces of longitudinal striæ and lines of growth. It is allied to European upper greensand forms.

Locality, Pondicherry.

4. *Arca Clellandi*, sp. nov. Pl. XVI. fig. 4.

A. testâ compressâ, anticè rotundatâ, posticè obliquè truncatâ, angulatâ, post angulum lævigatâ, reliquâ testâ regulariter radiato-sulcatâ, areâ angustissimâ, umbonibus approximatis.

Length $0\frac{4}{10}$ inch. Breadth $0\frac{5}{23}$ inch.

The surface of this shell and of the cast is marked by twenty-five radiating furrows, each twice as broad as the intermediate ribs. The space behind the angle is nearly smooth, or slightly marked by transverse furrows of growth. The posteal angle of the cardinal margin is very sharp. The dentition is obscure.

Locality, Pondicherry; a single specimen.

5. *Arca abrupta*, sp. nov. Pl. XIV. fig. 2.

A. testâ inflatâ, gibbâ, obliquè trigonâ, abruptè truncatâ, fortè carinatâ, carinâ elevatâ, longitudinaliter concentricèque striatâ, umbonibus approximatis, prominentibus.

Length 3 inches. Breadth the same. Height of a single valve $1\frac{1}{2}$ inch.

A remarkable gibbous triangular species, very abruptly truncate and carinate. The keel is elevated and the highest part of the shell. The truncation is marked by an obscure curved sulcus. It is allied to the *Arca decussata* and *Arca fibrosa* of the upper greensand of Blackdown, but is more sharply keeled and triangular than either. *Arca Beaumontii* of the French Craie chloritée is also its near ally.

Locality, Verdachellum.

6. *Arca trinchinopolitensis*, sp. nov. Pl. XV. fig. 16.

A. testâ inflatâ, gibbâ, subtetragonâ, abruptè truncatâ, carinatâ, angulo obtuso, post angulum subsinuatâ, sublævigatâ, reliquâ testâ decussato-striatâ; areâ parvâ, lanceolatâ, umbonibus prominentibus.

Length $1\frac{1}{2}$ inch. Breadth $3\frac{5}{10}$ inches. Height $1\frac{6}{10}$ inch.

Nearly allied to *Arca decussata* and to its allies. Young shells are striated all over. The hinge presents numerous small radiating teeth in the central portion and four oblique large ones at each side. The posterior muscular impression is strengthened by a ridge.

Locality, Trinchinopoly and Verdachellum. The specimens from the former place are somewhat wider.

Genus Pectunculus, Lamarck.

1. *Pectunculus subauriculatus*, sp. nov. Pl. XVII. fig. 13.

P. testâ obliquè-orbiculari, subauriculatâ, striis transversis longitudinalibusque ornatâ, umbonibus obtusis.

Length $0\frac{10}{12}$ inch. Breadth $0\frac{11}{12}$ inch.

Shell oblique, rounded, with obsolete ears, the surface marked with striæ both ways, the longitudinal striæ minute and very regular. It is allied to, but distinct from, the greensand *Pectunculus umbonatus*.

Locality, Pondicherry.

Genus Trigonia, Bruguière.

1. *Trigonia orientalis*, sp. nov. Pl. XVIII. fig. 11.

T. testâ transversè suborbiculari-ovatâ, depressâ, posticè latè subrostratâ, concentricè sulcatâ, plicis intermediis rotundatis, lævigatis, areâ sublævigatâ.

Length $1\frac{3}{4}$ inch. Breadth 2 inches.

Shell roundish ovate, depressed, marked by regular transverse sulcations, which are broader than the elevated smooth ribs which separate them. The posteal area is smooth, or nearly so. In the specimen figured there are about twenty-five transverse ribs.

Locality, Pon dicherry

2. *Trigonia suborbicularis*, sp. nov. Pl. XVIII. fig. 10.

T. testâ suborbiculari, subæquilaterali, posticè latè subrostratâ, concentricè sulcatâ, costis intermediis elevatis, læviusculis, areâ supernè lævigatâ, prope cardinem transversè striatâ.

The sulcations are much narrower and more numerous in this species than in

the last. The outline is also very different. They are however nearly allied, and, with the next, belong to a group of *Trigoniæ* (*T. affinis* and *T. excentrica* are examples) which in Europe are characteristic of the lower part of the Cretaceous system.

Locality, Pondicherry.

3. *Trigonia semiculta*, sp. nov. Pl. XVIII. fig. 9.

T. testâ obliquè obovatâ, depressâ, subrostratâ, tertiâ parte profundè regulariter transversè sulcatâ, reliquâ testâ lævigatâ.

Length $1\frac{11}{12}$ inch. Breadth $2\frac{4}{12}$ inches.

Depressed, obovate, broadly beaked; the beaked end smooth, the remainder of the shell for about two-thirds of its surface transversely sulcated by more than sixty shallow furrows. Near the beak the entire shell is sulcated across; so also is the young shell. The nearest relative of this species is the *Trigonia affinis* of the upper greensand.

Locality, Verdachellum.

4. *Trigonia aliformis*, Parkinson. Pl. XIV. fig. 3.

There are small, but well-preserved specimens of this species in the Verdachellum collection, which cannot be distinguished from British examples.

Genus Avicula, Bruguière.

1. *Avicula nitida*, sp. nov. Pl. XVI. fig. 6.

A. testâ lævi, tumidâ, obliquè trigonâ, anticè dilatatâ, compressâ, posticè acutè rostratâ, basi rostri abruptâ, umbonibus prominentibus, margine dorsali recto.

Oblique measurement from beak to foremost part of margin $1\frac{1}{4}$ inch. Dorsal line $1\frac{1}{2}$ inch. Thickness of united valves $0\frac{3}{4}$ inch.

A smooth, shining species, broadly triangular and considerably produced on the short side. It is a very distinct and rather peculiar form.

Locality, Pondicherry.

Genus Mytilus, Linnæus.

[Section A. *Mytilus* auctorum.]

1. *Mytilus nitens*, sp. nov. Pl. XVI. fig. 8.

M. testâ lævigatâ, transversè obscurè sulcatâ, ovato-lanceolatâ, lineâ cardinali rectâ, posticè sinuatâ, anticè rotundatâ, umbonibus prominentibus.

Oblique distance from beak to furthest margin $0\frac{7}{12}$ inch. Line of hinge $0\frac{5}{12}$ inch. Thickness of united valves $0\frac{3}{12}$ inch.

Resembling many known forms, both cretaceous, tertiary, and recent, but apparently sufficiently distinct from all.

Locality, Pondicherry.

[Section B. *Modiolus* auctorum.]

2. *Mytilus* (*Modiolus*) *cypris*, sp. nov. Pl. XVI. fig. 7.

M. testâ oblongâ, depressâ, lævi, marginibus parallelis, umbonibus subterminalibus, extremitatibus rotundatis.

Length from beak to extreme margin $0\frac{6}{10}$ inch. Breadth across the centre $0\frac{5}{23}$ inch.

Locality, Pondicherry. Specimen bad.

3. *Mytilus* (*Modiolus*) *typicus*, sp. nov. Pl. XIV. fig. 4.

M. testâ cuneato-oblongâ, convexâ, dorso tumido, margine frontali expanso transversè striato-costato, striis in latere cardinali fortioribus, elevatis, plerumque in medio bifurcatis, fasciculo obliquo striarum longitudinalium in centro dorsi decussatis.

Length from beak to margin 4 inches. Greatest breadth $1\frac{3}{4}$ inch.

A very remarkable form, combining the characters of several sections of this variable genus. The beaks are placed at the shortest end, very near it, and from them runs diagonally a tumid dorsal convexity to the anterior margin of the dilated opposite extremity. The dorsal margin is nearly straight, and angulated anteriorly. The dorsal side of the central ridge is marked by bifurcating striæ and the ridge itself by a bundle of fine oblique striæ marking its course. The space in front of the central ridge is nearly smooth.

Locality, Verdachellum.

4. *Mytilus* (*Modiolus*) *flagelliferus*, sp. nov. Pl. XVI. fig. 9.

M. testâ elongatâ, lanceolatâ, subarcuatâ, anticè dilatatâ, diagonaliter bipartitâ, divisione dorsali costis arcuatis flagellatis, ventrali lævigato, umbonibus obtusis, terminalibus.

Length from beak to farthest margin $4\frac{1}{2}$ inches. Greatest breadth at dilated end 1 inch. Median breadth $0\frac{3}{4}$ inch. Greatest thickness, valves united, $0\frac{7}{12}$ inch.

This species is remarkably razor-shaped, with very terminal beaks. The hinder half of the surface, which is divided into two parts by a diagonal obtuse ridge, is marked by curved ridges or ribs, which on the back are trifurcated, like a whip of three thongs. The front division is smooth, or marked by furrows of growth. The young shell is marked with obsolete longitudinal striæ. This species is nearly allied to the *Modiola plicata* of the Cornbrash, but in the latter the plications divide into twenty or even more thongs.

Locality, Pondicherry.

5. *Mytilus* (*Modiolus*) *pulcher*, sp. nov. Pl. XIV. fig. 6.

M. testâ tumidâ, valdè inæquilaterali, tetragonâ, obliquè carinatâ, carinâ diagonali, obtusâ, longitudinaliter transversèque striis minutis regularibus ornatâ; margine dorsali compresso, frontali subsinuato, umbonibus recurvis gibbosis (nucleo lævi, polito).

Beak to anterior angle $1\frac{5}{12}$ inch. Greatest breadth $1\frac{6}{12}$ inch. Greatest thickness $0\frac{9}{12}$ inch. Hinge-line $0\frac{8}{12}$ inch or a little more.

A very curious and beautiful form, which at first sight so closely resembles a *Cypricardia* or a *Myaconcha* that its relationship to *Mytilus* seems obscure. On close examination however, the hinge appears to be that of a *Mytilus*, and making allowances for exaggerations of parts, the general form does not really depart very far from that of some existing species of the section *Modiolus*. The fine striæ obliquely crossing each other on the surface of the shell confirm the relationship. When the shell is held up with its back towards the observer, the outline of the united valves appears nearly tetragonal. The cast is very smooth and highly polished.

Locality. It appears to be plentiful at Pondicherry.

Genus Pinna, Linnæus.

1. *Pinna arata*, sp. nov. Pl. XVI. fig. 10.

P. testâ lanceolatâ, compressâ, undique longitudinaliter regulariterque sulcatâ.

At $2\frac{1}{2}$ inches from the beak this *Pinna* measures $0\frac{10}{12}$ths of an inch broad. The fragment is 3 inches long. It appears to be distinct from any described or figured fossil form.

Locality, Pondicherry.

2. *Pinna restituta*, Hoeninghaus.

Fragments of considerable size from Pondicherry, undistinguishable from this greensand species.

3. *Pinna decussata*, Goldfuss.

Fragments of a fine *Pinna* occur in the Verdachellum collection, which appear to be identical with the species so named from the cretaceous strata of Westphalia.

Genus Pecten, Bruguière.

1. *Pecten quinquecostatus*, Sowerby.

Of this very characteristic cretaceous species there are specimens in the collection, from both Pondicherry and Verdachellum, which cannot be distinguished from specimens from the greensand of Blackdown.

2. *Pecten obliquus*, Sowerby.

In the Verdachellum collection are specimens not to be distinguished from the lower greensand *Pecten obliquus* of the beds in the Isle of Wight.

3. *Pecten orbicularis*, Sowerby?

A fragment not sufficiently perfect to admit of certain identification.
Locality, Verdachellum.

4. *Pecten virgatus*, Nilsson. Pl. XV. fig. 22.

Two very perfect valves, differing in no essential particulars from the European greensand form.
Locality, Trinchinopoly.

5. *Pecten verdachellensis*, sp. nov. Pl. XIV. fig. 5.

P. testâ orbiculari, depressâ, longitudinaliter costatâ, costis numerosissimis, tenuibus, squamosis, alternatis majoribus; auriculis æqualibus radiato-costatis.
Length and breadth $1\frac{8}{12}$ inch.

In most of the specimens the scales of the rays of this very distinct Pecten are worn away, so that the latter appear as if crossed by numerous thread-like striæ. The cast is more or less smooth, but exhibits traces of the ribs and scales towards the margin.
Locality, Verdachellum.

Genus Lima, Bruguière.

1. *Lima obliqui-striata*, sp. nov. Pl. XVIII. fig. 13.

L. testâ obliquâ, ovatâ, convexâ, longitudinaliter costatâ, transversè (obsoletè) striatâ; striis lateralibus obliquis.
Length $0\frac{8}{12}$ inch. Breadth $0\frac{6}{12}$ inch.

Resembling *Lima undata* in outline. Remarkable for having the numerous longitudinal ribs crossed by transverse striæ which become oblique towards the sides. It is nearly allied to *Lima granulata* from the greensand of Westphalia, figured by Goldfuss, pl. 104. fig. 5.
Locality, Verdachellum.

Genus Spondylus, Linnæus.

1. *Spondylus subsquamosus*, sp. nov. Pl. XVIII. fig. 1.

S. testâ obliquâ, suborbiculari, valvâ dextrâ complanatâ, affixâ, longitudinaliter striatâ et transversè plicatâ; valvâ sinistrâ convexâ, sulcatâ, sulcis numerosissimis regularibus longitudinalibus, costis elevatis acutis, ad marginem squamis paucis.

Lower valve with beak 3 inches long. Breadth $2\frac{3}{4}$ inches. Thickness $2\frac{1}{4}$ inches. Upper valve $2\frac{1}{2}$ inches in length.

This fine species has the smaller valve very regularly eared. The sculpture of the surface is regular, and varied by a few arched scales placed at irregular distances towards the margin. There are traces of decussating striæ between the ribs. The beak is triangular. It is nearly allied to the Neocomian *Spondylus Roemeri*, described by Deshayes.

Locality, Pondicherry.

2. *Spondylus calcaratus*, sp. nov. Pl. XVIII. fig. 2.

S. testâ ovatâ, obliquâ, valvâ dextrâ affixâ, ad umbonem rostratâ, longitudinaliter striatâ, transversè plicatâ; valvâ sinistrâ convexâ, longitudinaliter sulcato-striatâ (interstitiis rotundatis), obsoletè nodulosâ.

The largest specimen measures 4 inches, without beak, in length. A middle-sized individual has the following proportions. Length of upper valve $3\frac{4}{12}$ inches; of lower valve with its beak 4 inches. Breadth of either valve $3\frac{3}{4}$ inches. Length of beak $0\frac{1}{4}$ inch. Breadth about $1\frac{1}{2}$ inch. Thickness $1\frac{3}{4}$ inch.

Very nearly allied to the last, but presenting differences which induce me to regard it as specifically distinct. The large and differently formed beak, the rounded instead of sharp ribs, and the nodulose surface serve to distinguish it.

Locality, Pondicherry.

Genus Plicatula, Lamarck.

1. *Plicatula septemcostata*, sp. nov. Pl. XVIII. fig. 4.

P. testâ subobliquâ, suborbiculari, convexiusculâ, inæquivalvi, longitudinaliter costatâ, costis septem majoribus, subangulatis (subsquamosis); apice affixâ.

Length $1\frac{2}{12}$ inch. Breadth $1\frac{2}{12}$ inch. Thickness of united valves $0\frac{5}{12}$ inch.

A nearly orbicular, slightly oblique shell, depressed and inequivalve. The surface is ribbed longitudinally; seven of the ribs rise prominently and angularly. The nearest allies of this species are oolitic.

Locality, Pondicherry.

2. *Plicatula multicostata*, sp. nov. Pl. XVIII. fig. 3.

P. testâ ovatâ, depressâ, longitudinaliter costatâ, costis numerosis, alternatis minoribus abbreviatis.

Length $0\frac{7}{12}$ inch.

A species allied to some cretaceous forms, and well-marked by the peculiar arrangements of the numerous ribs, which are alternately larger and smaller, the smaller ones stopping short.

Locality, Verdachellum.

Genus Gryphæa, Sowerby.

1. *Gryphæa stomatoidea*, sp. nov. Pl. XVII. fig. 15.

G. testâ inferiori ovatâ, transversè obsoletè sulcatâ, in dorso excentricè turgidâ, umbone intorto, sessili.

Greatest length $2\frac{2}{12}$ inches. Breadth below beak $1\frac{3}{13}$ inch. Length from keel to margin $1\frac{1}{12}$ inch. Height $0\frac{5}{12}$ inch.

The more or less carinated turgid back, so keeled that it exhibits a long slope towards the intorted beak, distinctly marks this *Gryphæa*, which in many respects is nearly allied to the *Exogyra* (*Gryphæa*) *subcarinata* of Count Munster, a species from the greensand of Westphalia.

Locality, Pondicherry.

2. *Gryphæa orientalis*, sp. nov. Pl. XIV. fig. 6.

G. testâ ovato-trigonâ, lævigatâ, haliotoideâ, gibbâ, carinatâ, carinâ sublaterali.

Length 5 inches. Breadth 4 inches. Greatest height $1\frac{3}{4}$ inch.

This large *Gryphæa* closely resembles the *Gryphæa sinuata* and *G. lævigata* of the lower greensand. It differs slightly in habit and more importantly in having the widest slope from the keel on the side of the beaks, and not, as in the European species named, on the opposite side.

Locality, Verdachellum.

Genus Ostrea, Linnæus.

1. *Ostrea pes-leonis*, sp. nov. Pl. XVIII. fig. 5.

O. testâ crassâ, ovatâ, subarcuatâ, irregulariter longitudinaliter radiato-sulcatâ, sulcis in plicis fortissimis ad marginem externum mutatis, abruptis, angulatis.

Length $4\frac{7}{12}$ inches. Breadth $2\frac{1}{2}$ inches. Greatest height $2\frac{1}{4}$ inches.

A ponderous, ovate, slightly bent shell, deeply but irregularly sulcated longitudinally, the furrows towards the margin becoming very deep, angular, and separated by very strong, high, ridgy, acutely angular plications. It closely resembles the *Ostrea Marshii* of the English oolites, but appears to be specifically distinct.

Locality, Pondicherry.

2. *Ostrea tegulanea*, sp. nov. Pl. XVIII. fig. 6.

O. testâ æquivalvi, lineari-lanceolatâ, arcuatâ, dorso sulcato, sulco lævi, æquali; lateribus abruptis, plicis numerosis truncato-squamosis, ad dorsum abruptè prominentibus; latere interno dimidio expanso, plicis angustioribus arcuatis.

Length of largest valve $3\frac{1}{2}$ inches. Breadth at the expanded part $1\frac{3}{4}$ inch. The specimen figured was smaller, but exhibits all the proportions and characters of the shell in great perfection.

On all the specimens there are fifteen plications on the outer side, seven on the expansion, and six on the inner unexpanded portion of the shell. The canal of the back is very regular. The near allies of this species are *Ostrea carinata*, *O. pectinata* and *O. larva*, all cretaceous.

Locality, Pondicherry.

3. *Ostrea amorpha*, G. B. Sowerby, MSS. Pl. XV. fig. 24.

O. testâ irregulari, crassâ, subæquivalvi, valvâ superiori obtusè plicatâ.
Length 2 inches. Breadth 1 inch.

Whilst there can be no question that this formless oyster is distinct from any other species in the collection, it is impossible to describe it in more definite terms than those given in the diagnosis.

Locality, Trinchinopoly.

4. In the Verdachellum collection are bad specimens of a fourth species of Oyster, very nearly allied to, if not identical with, the greensand *Ostrea prionota*; but better examples are required for certain determination.

Articulata.

Crustacea.

The carapace of a Crab is contained in the Pondicherry collection, and is represented in Plate XVI. fig. 12.

Annelida.

Genus Ditrupa, Berkeley.

1. *Ditrupa? longissima*, sp. nov. Pl. XIX. fig. 13.

D. testâ cylindricâ, longissimâ, arcuatâ, concentricè regulariter striatâ, striis minutissimis (nucleo lævi).
Length of specimen $4\frac{1}{2}$ inches. Diameter $0\frac{1}{10}$ inch.

A very long, regularly curved, cylindrical shell. The surface is marked with very minute concentric striæ. The cast is smooth. The habit is so truly that of a testaceous tubicular Annelide, and the regularity of form so similar to the aspect of a *Ditrupa*, that, although the mouth is not preserved, I have little hesitation in referring it to that well-marked genus.

It is contained in a mass of rock from Pondicherry, and is associated with *Baculites* and various univalve and bivalve shells.

Echinodermata.

Ophiuridæ.

Genus Ophiura, Lamarck.

1. *Ophiura? Cunliffei*, sp. nov. Pl. XIX. fig. 8.

Part of the disc and arms of a very distinct species, apparently belonging to the typical genus *Ophiura*, and evidently allied to the *Ophiura serrata* of Römer, a species found in the white chalk of Germany and of England. The plates of the disc in the Indian fossil are larger than in any known species of the genus. The disc-shields at the bases of the rays are broadly oblong and somewhat triangular. The scales of the centre of the arms are small and angular; the lateral scales are very large and oblong. The spines are not preserved, but were probably short and obtuse. The figure represents the specimen of the natural size. It was found by Mr. Cunliffe at Verdachellum.

Echinidæ.

The greater part of the specimens of Urchins in this collection were presented by Mr. Cunliffe through Mr. Egerton. Not having been kept so carefully distinct as the shells were, and all the specimens being free from rock, their locality, whether from Pondicherry or Verdachellum, has not been marked. No specimens of Echinidæ are contained in the Trinchinopoly collection.

Genus Holaster, Agassiz.

Of this genus of *Spatangaceæ* there is a single species in the Pondicherry collection. The genus *Holaster* was established by Agassiz for a group of Urchins differing from *Spatangus* in the arrangement of the latero-dorsal ambulacra, which in the former are radiate and not petaloid, and never placed in depressions. I have for some time been inclined to dispute the propriety of the separation from *Spatangus* of the species presenting these characters, dreading the tendency of many distinguished living naturalists to extreme multiplication of generic groups. Such a practice is unsafe, even in the hands of an Agassiz, and highly dangerous when indulged in by those whose studies have been confined to limited departments of natural history. If carried too far, it will assuredly lead to much confusion, since, when every alliance of a few species presenting unimportant characters in common is elevated to generic rank and endowed with a generic appellation, the natural-history language by means of which general views can be expressed,

will be rendered unintelligible to all but those minutely acquainted with specific zoology and botany. As the giving a name to a group at all is merely an arrangement of convenience—since a numerical sign or a letter would serve all purposes for the student in his closet—the extreme multiplication of names converts the practice into an abuse, and tends to mystify and confuse the science. On the *equal value of generic terms*, the value of natural-history statistics, whether as serving to elucidate the modifications of form or structure in the animal or vegetable series, or as furnishing data for working out the equally important subject of distribution in time and space, must depend. *Genera* therefore should not, it seems to me, be founded without deliberate consideration, full knowledge, and an earnest conviction of the organic importance of the characters on which we base a new genus. Neither genus nor species should be admitted which has not been or may not be clearly defined *in words*; and in the case of the former, if not of the latter also, strong objections might be offered to the employment of merely *comparative* characters alone.

The arrangements of the ambulacra already mentioned, the absence of a dorsal impression, which indicates peculiarities in the arrangement and form of the animal's burying-organs (its spines), taken in conjunction with a peculiar habit, recognisable at a glance, are all organic characters of sufficient importance to warrant the constitution of the genus *Holaster*; and their value is borne out by the peculiar distribution of this genus (now extinct) in time, all its species but one being concentrated, as it were, in the Cretaceous epoch.

1. *Holaster indicus*, sp. nov. Pl. XIX. fig. 4. *a*, *b*.

H. cordatus, inflatus, posticè altior, extremitate anali obtusè rostratâ, infrà spatio post-orali convexâ, subcarinatâ.

Length $1\frac{6}{10}$ inch. Breadth $1\frac{1}{2}$ inch. Greatest height 1 inch.

Very regularly heart-shaped, nearly as broad as long. Back most convex posteriorly in the space between the two postero-lateral ambulacra. Behind the highest part the body contracts a little as if pinched in, and is narrowly truncated at the anal extremity. The anterior extremity is deeply cordate. The series of pores forming the ambulacra gently diverge, and almost all nearly equally. In each series of the four dorsal ambulacra there are about twenty-four pairs of open pores, the last five being placed distant from each other. The pairs of the several series are not connected by grooves. The anal area is vertically oblong. On the under-surface the most prominent part is the post-oral space, which is oblong, very convex, and has a tendency to carination. The antero-lateral portions (cheeks) are rather tumid.

The nearest allies of this species are the *Holaster suborbicularis* from the upper

chalk of Maestricht and equivalent formations*. That species, however, has the apex of the back in the region of the ocelli. The Indian species has a narrower anterior groove. It is also allied to the *Holaster l'Hardy* of the Neuchâtel greensand, but differs in the disposition of the ambulacra.

Genus Brissus, Klein.

(Including *Micraster*, *Schizaster*, and *Brissopsis* of Agassiz.)

1. *Brissus expansus*, sp. nov. Pl. XIX. fig. 7.

B. ambitu suborbiculari; dorso depresso, vertice centrali; ambulacris impressis, antero-lateralibus longioribus, posticis lanceolatis, sulco antico profundo, lateribus abruptis, parallelis; infernè spatio post-orali latè ovato.

Length $2\frac{6}{10}$ inches. Breadth $2\frac{7}{10}$ inches. Greatest height $1\frac{5}{10}$ inch.

Nearly round, or very broadly cordate, depressed but convex. The dorsal ambulacra are all petaloid and narrow, the antero-laterals being to the posterior ones as three to two. The former have about thirty-two pairs of pores, connected by grooves, in each series; the latter about twenty-three. The ambulacral impressions are flat centrally, and the lowermost pore of each pair is advanced a little towards the centre of the plane. The junction of the ambulacral plates in the centre of the depressions appears as a fine undulated ridge. The anterior central ambulacral groove is rather narrow and has very steep parallel sides. The anal end is very obtuse and the truncation slopes rapidly towards the under-surface. The post-oral space is broadly ovate and rather convex, but the cheeks are nearly flat.

This *Brissus* is allied to a common miocene form from Malta.

2. *Brissus inæqualis*, sp. nov. Pl. XIX. fig. 6.

B. ambitu orbiculari-cordato, dorso depresso, vertice subcentrali; ambulacris leviter impressis, antero-lateralibus multò longioribus, posticis ovatis, sulco antico lateribus divergentibus; infernè spatio post-orali latè ovato.

Length $1\frac{8}{10}$ inch. Breadth $1\frac{8}{10}$ inch. Greatest height $0\frac{7}{10}$ inch.

Orbicularly cordate, depressed, but more convex than the last species, to which it is very nearly allied. The sides are more sloping. The frontal furrow is deep, and gradually widens. The antero-lateral ambulacra are very long, and have nearly parallel sides through the greater part of their length. The postero-lateral ones are very short and ovate. The former have twenty-five pairs of pores connected by grooves, placed on the slope of the depression in each series. The latter only

* It is said to occur in greensand at Lyme Regis in England.

twelve or thirteen pairs. The postero-lateral depressions are deepest. The anal truncation is nearly perpendicular. Beneath, the cheeks are very flat or almost concave, and the post-oral space is slightly convex and broadly ovate.

3. *Brissus Rana*, sp. nov. Pl. XIX. fig. 5.

B. ambitu suborbiculari, subangulato, dorso elevato, vertice subcentrali (postico); ambulacris profundè impressis, antero-lateralibus longioribus lanceolatis, posticis ovatis, sulco antico profundo, lato, lateribus subdeclivis, infernè spatio post-orali latè ovato.

Length $1\frac{1}{2}$ inch. Breadth $1\frac{6}{10}$ inch. Greatest height $1\frac{2}{10}$ inch.

A very tumid, subglobose species, slightly broader than long and rather angular in outline. The sides slope steeply. The anal extremity is suddenly and perpendicularly truncate. The anterior and central furrow is rather wide, and has sides which appear to slope, owing to the rounding of their angles. This furrow is not so deep as the latero-dorsal ambulacra. The anterior pair are lanceolate, and the posterior ovate, approximate and very deep. In the former are twenty-three pairs of pores in each series, placed on the slopes of the depression; in the latter eighteen. Beneath, the surface is convex posteriorly in consequence of the form of the post-oral space, but the cheeks are nearly flat.

The nearest allies of this species are tertiary. The chalk "*Spatangus Bucardium*" of Goldfuss also comes near it.

Genus Nucleolites, Lamarck.

Under this generic term I would include all the *Clypeasteridæ* with petaloid interrupted ambulacra and a supra-marginal anus. The genera *Clypeus*, *Nucleolites*, *Cassidulus*, *Catopygus*, and *Pygorhynchus*, are so many sections, not always very definite, of the genus so constituted. The following table will show their relations at a glance:—

- A. Anal furrow strongly marked .....
  - Anus placed high up.
    - Mouth with tubercles..... = *Clypeus* (Klein), Agassiz.
    - Mouth without tubercles ..... = *Nucleolites*, as restricted by Agassiz.
  - Anus placed far back.
    - Mouth with tubercles..... = *Pygorhynchus*, Agassiz.
    - Mouth without tubercles ..... = *Catopygus*, Agassiz.
- B. Anal furrow obsolete ..... (Mouth with tubercles) = *Cassidulus*, Lamarck.

1. *Nucleolites* (*Pygorhynchus*) *testudo*, sp. nov. Pl. XIX. fig. 2. *a*, *b*.

N. ovatus, gibbosus, vertice supra-anali, marginibus declivis, sulco anali lanceolato, declivi.

Length $1\frac{4}{10}$ inch. Breadth $1\frac{1}{10}$ inch. Height $0\frac{7}{10}$ inch.

Oval, gibbous in the centre, with very abrupt sloping sides. The highest part is in the posterior ambulacral space. The posterior extremity slopes rapidly to the margin and includes the long anal groove. The dorsal ambulacra are very regularly lanceolate and stellate. The pairs of pores are connected by grooves, which are not easily seen, either owing to the imperfection of the specimens, or from their having been originally obsolete. The under-surface is very concave. The mouth is rather excentric, and is surrounded by five strong tubercles, between which radiate in star-like fashion five ovate ambulacra. The spinigerous tubercles of the under-surface are very strongly marked.

2. *Nucleolites* (*Pygorhynchus*) *planatus*, sp. nov. Pl. XIX. fig. 3, *a*, *b*.

N. latè ovatus, depressus, vertice centrali, sulco anali oblongo, verticali.
Length $1\frac{4}{10}$ inch. Breadth $1\frac{2}{10}$ inch. Height $0\frac{1}{2}$ inch.

Broadly ovate, rounded at both ends, much depressed, with gradually sloping sides. The highest portion is in the true centre, but from that to the summit of the anal furrow the depression is very slight. The posterior dorsal ambulacra slightly diverge. The anus is placed in a deep, short vertical furrow. The under-surface is very concave. The mouth is excentric and surrounded by five strong tubercles, between which are the broadly-ovate oral ambulacra. The spinigerous tubercles of the under-surface are strongly marked.

3. *Nucleolites* (*Cassidulus*) *elatus*, sp. nov. Pl. XIX. fig. 1. *a*, *b*, *c*, *d*.

N. convexus, tumidus, vertice planato, subcentrali, lateribus abruptè declivis ; infrà planus ; anus rotundus, prope marginem posteriorem.
Length $2\frac{1}{2}$ inches. Breadth $2\frac{2}{10}$ inches. Height $1\frac{2}{10}$ inch.

Subglobose, flat beneath, very convex above. Summit obliquely depressed, the highest part being behind the centre, sides very steep but sloping. Dorsal ambulacra lanceolate. Anus round, impressed, placed above the margin (which is slightly beaked) at about one-third the height of the side. Mouth slightly excentric, surrounded by five oblong tubercles which are grooved centrally; between them are the diamond-shaped oral ambulacra, each with an oblong central tubercle separating the series of pores, forming a beautiful star-like arrangement. The spinigerous tubercles of the ventral surface are much developed.

Zoophyta.

Helianthoida.

Genus Fungia, Lamarck.

1. *Fungia filamentosa*, sp. nov. Pl. XIX. fig. 11.

F. testâ semiglobosâ, circulari, suprà elevatâ, convexâ, depressione centrali elongatâ, parùm profundâ; lamellis numerosissimis, tenuissimis, regularibus, æqualibus, simplicibus; basi concavâ, lævigatâ, radiato-striatâ; striis numerosissimis, simplicibus, æqualibus, lineis distantibus incrementi vix interruptis; margine acuto.

Diameter $0\frac{7}{10}$ inch. Height $0\frac{4}{10}$ inch.

The smoothness of the excavated base and extreme regularity of the very fine lamellæ distinguish this *Fungia* from most described forms. It belongs to the group usually referred to *Cyclolites*. The *Cyclolites discoidea* of Blainville (a greensand fossil) is its nearest ally. *C. elliptica* of Lamarck, a nummulitic limestone species, is also nearly allied to it.

Locality, Pondicherry.

Genus Turbinolia, Lamarck.

1. *Turbinolia arcotensis*, sp. nov. Pl. XIX. fig. 9. *a*, *b*.

T. testâ cylindricâ, conicâ, elongatâ, disco excavato, lamellis (30) fortibus radiato; lateribus undulatis, striatis, striis tenuibus, confertis, regularibus, æqualibus.

Diameter of disc $0\frac{6}{10}$ inch. Entire length (or height) $1\frac{2}{10}$ inch.

A conical species, usually slightly bent, with finely and regularly striated sides, and a star of many strong prominent lamellæ. The specimens are rarely well-preserved. The species is gregarious. It approaches nearly several cretaceous and also some tertiary forms.

Locality, Pondicherry.

Genus Cladacora, Ehrenberg.

In the Pondicherry collection are fragments of a coral apparently belonging to this genus. They are cylindrical, slightly undulated, and closely and regularly longitudinally striated. (Plate XIX. fig. 10.) In the absence of better specimens I abstain from giving any specific appellation.

Bryozoa.

Traces of incrusting corals of this order, probably belonging to *Flustra* and *Lepralia*, are seen on several shells in the collection, but not sufficiently perfect to warrant definition.

Part the Second.—*Inferences drawn from a study of the Species.*

The total number of species of Invertebrata collected by Mr. Kaye and Mr. Cunliffe in ancient fossiliferous beds of South-Eastern India, and presented to the Geological Society, is 178, of which 165 are Mollusca, two Articulata, eight Echinodermata, and three Zoophytes. The greater proportion are from Pondicherry; Verdachellum and Trinchinopoly furnishing comparatively few. The deposits at the three places named are connected with each other zoologically by the associations of certain species common to two of them with others found in the third. Thus, *Pecten quinquecostatus* and *Panopæa orientalis* occur in both Pondicherry and Verdachellum beds; *Voluta cincta* at Pondicherry and Trinchinopoly; *Chemnitzia undosa* and *Cardium Hillanum* at Verdachellum and Trinchinopoly. These identifications are so certain, that there can be no question of the mutual geological relations of the beds and of their being members of one system. In what geological epoch that system should be placed is the first inquiry to which we seek an answer.

At first glance the assemblage of specific forms in this collection seems very anomalous to the European geologist. Accustomed to regard certain generic forms as decided indications of secondary and others of tertiary age, he sees in these Indian fossils numerous species associated, lying side by side in the same stratum, which if found in separate beds would have led to the inference of their having lived at very different and distant epochs. Thus in the Pondicherry beds we have numerous species of *Ammonites*, *Baculites*, *Hamites* and other genera, distinctly of secondary age, associated with varied forms of *Voluta*, *Oliva*, *Cypræa*, *Murex*, and other genera which are usually regarded as characteristic of strata of tertiary origin. Indeed the latter so prevail in the Trinchinopoly part of the collection, that had it alone been brought to Europe, no other inference could have been drawn from it safely than that the strata at Trinchinopoly were decidedly tertiary.

When however we examine the whole collection critically—species by species—we find that its tertiary aspect is more in appearance than in reality. Out of the numerous species in this invaluable collection, very few indeed are described forms. But there are a few well-known European species in it, and every one is *cretaceous*. It happens fortunately that some of these occur in all three collections. In the Pondicherry collection we find *Pecten quinquecostatus*, one of the most characteristic of cretaceous species; a *Pinna* undistinguishable from *Pinna restituta*; two beautiful Ammonites (*A. Juilleti* and *A. Rouyanus*), between which

and the French "Neocomian" species, whose names I have adopted, I can draw no specific distinctions; and two *Nautili* which appear to be identical with the *Nautilus lævigatus* and *Nautilus clementinus* of M. D'Orbigny, species from cretaceous beds in France. In the Verdachellum collection we have *Pecten quinquecostatus* again, quite undistinguishable from Blackdown examples, *Pecten obliquus*, precisely the same as specimens from the Isle of Wight, and fragments of a *Pecten* apparently identical with our *Pecten orbicularis*. Also *Trigonia aliformis* and *Cardium Hillanum*, very characteristic cretaceous forms, and an Oyster, in all probability one of our greensand species. In the Trinchinopoly collection are *Cardium Hillanum*, apparently common, and a *Pecten* which I cannot separate from the greensand *Pecten virgatus*.

On the other hand, however similar at first glance some of the shells may seem to tertiary species, on close inspection they have, every one, proved to be distinct. So far then as positive identifications go, the plain inference respecting the age of the beds at the three localities is, that they are *Cretaceous*.

However clear this conclusion may appear, it cannot be unhesitatingly received, even upon such evidence, in the case of beds so far distant and under such very different circumstances of climate, &c., from any cretaceous beds with which we are sufficiently acquainted. It might be that in the region in which these strata were formed, certain species had lived on to a later epoch than they had in less-favoured localities; or, having commenced their existence at one point in space at an early epoch, they might in the course of time become so distributed, that at length, in consequence of changes in the distribution of land and water, they would survive at a later period only in some sea far removed from their birthplace. These possibilities must always be taken into account in all comparisons of geological formations far apart. Except in the case of species known to have an extended vertical as well as horizontal range and yet to be distinctly limited to an epoch, it is dangerous to draw conclusions as to the synchronism of beds under such circumstances. In this case, however, the bivalve mollusca named as identical with European species are all widely distributed forms, and yet everywhere distinctly cretaceous.

But the inference of the cretaceous date of the Southern Indian beds is borne out by, to my mind, higher considerations than such identifications of species. Among the facts of a general character made known to us by palæontological research, there is, perhaps, none more interesting than the restriction of the minor groups in large genera, capable of considerable and definite variations of form, to limited portions, so to speak, of time, and the consequent indication afforded us of the probable age of the strata in which they occur, in the absence of familiar forms. This is also true of the arrangement in time of genera in certain families. *Ammo-*

nites and *Terebratula*, and the several genera of *Cephalopoda* and *Echinidæ*, are familiar examples. The inestimable researches of Von Buch have, above all others, furnished us with this invaluable key to the ages of deposits, one which will assuredly prove in the end of far greater importance than the identification of strata by identical fossils. In the collections before us there are fortunately numerous forms, above all others capable of furnishing us with such a clue to the age of the beds. The fossil Cephalopods, so beautifully preserved in this collection, are so numerous and so varied that they alone might settle the question. Twenty-one out of twenty-eight well-marked *Ammonites* belong to sections of that great genus, pre-eminently and characteristically cretaceous, and of the seven remaining, five are the near allies of cretaceous forms. The *Hamites*, *Baculites* and *Ptychoceras* all have similar relations. The Gasteropoda, though at first sight more like tertiary than cretaceous forms, include many very nearly allied to known upper and lower greensand species. The *Pleurotomariæ* of the collection are peculiarly cretaceous. The genera *Tornatella*, *Strombus*, *Rostellaria*, *Murex*, *Pyrula*, *Vermetus* and *Nerita*, though the association of them appears tertiary, have all representatives in the cretaceous strata of Europe, and some in older rocks. *Voluta* itself, the genus which contributes most to the tertiary aspect of the collection, has representatives, and those not peculiar forms, as low down as the upper greensand in Europe, and occurs also in cretaceous strata in North America. *Turritella*, *Cerithium*, *Dentalium* and *Trochus* are genera represented in more ancient formations, and, owing to the peculiarities of their sculpture, as likely to present resemblances to recent forms in the oldest beds as in the newest. *Chemnitzia*, *Scalaria*, *Eulima*, *Ringicula* and *Natica* are genera having no greater weight in the argument for similar reasons, or else on account of their fossil relations being at present insufficiently known. There are three genera however among the Pondicherry Gasteropoda hitherto unrepresented in formations older than the tertiary epoch: these are *Cypræa*, *Oliva* and *Calyptræa*. The determination of the last is doubtful, but the species of the two former certainly have their nearest allies among tertiary and recent forms.

Every genus of bivalve testacea in the collection is already known in cretaceous strata or older. The peculiar forms of *Cardium*, *Arca*, *Trigonia*, *Mytilus*, *Pholadomya* and *Gryphæa*, all genera presenting subdivisions remarkably limited in their distribution in time, are characteristically cretaceous. The species of *Panopæa*, *Anatina*, *Pectunculus*, *Nucula*, *Lima*, *Pecten*, *Plicatula*, *Clavagella* and *Solecurtus* are all most nearly related to described European cretaceous forms of those genera. The tertiary aspect of the Trinchinopoly beds is derived from the presence of numerous bivalves recalling recent forms, but really more from their state of preservation than from being more nearly allied to recent shells than cretaceous

species of the same genera in Europe. This may be said of the examples of *Venus*, *Mactra* and *Psammobia*, genera in which the characters, so far as form is concerned, are not likely to present extreme modifications at any epoch. The same is true of *Cardita*, *Pinna*, *Avicula* and *Spondylus*, associated in the Pondicherry beds.

The few *Echinodermata* in the collection lead to similar conclusions. The species of *Holaster* and *Nucleolites* are characteristically cretaceous forms, and though the *Brissi* are perhaps most nearly allied to described tertiary species, there are others not very far removed in European cretaceous beds. The few Zoophytes are such as to lead to no conclusion of importance either one way or the other.

Were these beds tertiary or bordering on tertiary, in such a tropical region, we should expect to find examples of genera still abounding there, and common in tertiary strata of more northern latitudes,—examples of *Conus* and *Pleurotoma* for instance; but there are none. Moreover, admitting for a moment their tertiary origin, we might reasonably expect that the species in the collection identical with described forms would, if anything, be identical with the tertiary forms found in the Cutch beds; but it is not so. The collections of Captain Grant and Captain Smee furnish no identifications. We find them all in cretaceous strata as far away as Europe.

But though the closer we inquire into the evidence afforded by these fossils of the age of the beds in which they are contained, the more clear does it become that they are cretaceous, we have still to seek a reason for that mixed cretaceous and tertiary *facies* presented by the assemblage at first glance, and which led to doubts respecting the epoch of the Southern Indian strata. It doubtless depends on the greater development of generic forms, which though, as we have seen, with only three exceptions, also known in cretaceous strata in Europe, are yet so rare with us and so comparatively prevalent in the Indian beds, whilst many of them are familiar as characteristic of tertiary beds in Europe, that we are naturally inclined at first sight to associate with their presence the notion of a tertiary origin for the beds in which they occur. It appears to me that the right inference from their presence (since not one of the species is identical with any known tertiary form) is, not that the deposits containing them are either tertiary or necessarily connected with tertiary, but that the genera in question commenced their appearance or attained a great development *earliest* in the Eastern Seas, which, when we recollect that in those very seas at the present day are found the great specific assemblages or capitals of those genera, whilst they have either disappeared or have few representatives in the seas of other geographical regions, is exactly what we should expect, *à priori*, to find. This fact would go far to support the theory, that genera, like species, had geographical birthplaces, as they have geographical capitals or centres.

Respecting the relative ages of the three deposits (Pondicherry, Verdachellum and Trinchinopoly) in which the species described have been collected, two of them, Verdachellum and Trinchinopoly, appear to belong to a different epoch of the cretaceous æra from Pondicherry. The two former have several species in common (and those species among the most prolific in individuals) which are not found in the third. In them are found most of the species identical with European forms. In several of the genera, found at Pondicherry as well as at the places named, the forms are altogether distinct; although, judging from the evidence afforded by mineral character and association of species, the conditions of depth and sea-bottom at the time of the deposition of the strata seem to have been the same. The difference therefore must have depended on a representation of species by species in *time* and not in *depth*.

The beds apparently contemporaneous, viz. Trinchinopoly and Verdachellum, may be regarded as equivalent to the upper greensand and gault. The European species they include are either characteristic upper greensand and gault forms, or else such as occur in those strata. The new species they contain are either closely allied to known upper greensand or gault species, or peculiar to the Indian beds. On the other hand, the Pondicherry deposit may be regarded as belonging to the lowest division of the cretaceous system. In it almost all the fossils are new. Such as are analogous to known species are allied to fossils of the lower greensand of English geologists, and Neocomien of the French. In the genus most developed in this deposit, viz. *Ammonites*, three-fourths of the species belong to sections especially characteristic of the "Lower Neocomian" of the Mediterranean basin, whilst of the remainder as many representatives of oolitic fossils occur as of upper greensand species. The resemblance between many of the Pondicherry Ammonites and those of Castellane in the south of France is very remarkable.

Considered in regard to the distribution of animal life during the cretaceous epoch, this collection is of the highest interest. It shows that during two successive stages of that æra, the climatal influence, as affecting marine animals, did not vary in intensity in the Indian, European and American regions, whilst the later of the two had specific relations with the seas of Europe which are not indicated by the earlier. The cause of this remarkable fact is not to be sought in a more general distribution of animal life at one period than at another, but rather in some great change in the distribution of land and sea, and in a greater connexion of the Indian and European seas during the epoch of the deposition of the upper greensand than during that of the lower.

The fact, that of the few species found in these Indian cretaceous beds which are common to analogous beds in distant regions, the majority are such as have a great vertical range, supports the law pointed out by M. de Verneuil and Count D'Ar-

chiac with respect to palæozoic fossils, and by myself among tertiary and recent forms, viz. that the range of the geographical distribution of species is usually correspondent to the range of their distribution in time.

We have already seen that this collection affords strong evidence in favour of the proposition, that the marine faunas of distant localities, under similar conditions of climate, depth and sea-bottom, maintain their relations rather by the representation of forms by similar forms than by identity of species.

In every point of view this collection is of the highest interest. The fossils are as beautiful as they are interesting, and specimens of the finer species seem to be abundant. It is most desirable that further inquiries be made into the stratigraphical relations of the beds whence they were procured. Verdachellum and Trinchinopoly will doubtless yield many more species than have yet been brought to Europe.

EXPLANATION OF THE PLATES.

Plate VII.

Fig. 1 *a*. *Ammonites Garuda*: *b*. back view: *c*. septal suture.
2 *a*. *Ammonites Juilleti*: *b*. back view: *c*. septal suture.
3 *a*. *Ammonites Rembda*: *b*. its keeled back.
4 *a*. *Ammonites Yama*: *b*. back view.
5 *a*. *Ammonites Pavana*: *b*. back view.
6 *a*. *Ammonites Siva*: *b*. back view: *c*. septal suture.
7 *a*. *Ammonites Soma*: *b*. back view: *c*. septal suture.
8 *a*. *Ammonites Ganesa*: *b*. back view: *c*. septal suture.
9 *a*. *Ammonites Vishnu*: *b*. back view: *c*. septal suture.
10 *a*. *Ammonites Surya*: *b*. back view.
11 *a*. *Ammonites Durga*: *b*. back view.

Plate VIII.

Fig. 1 *a*. *Ammonites Brahma*: *b*. outline of back: *c*. a young shell: *d*. septal suture.
2 *a*. *Ammonites Cunliffei*: *b*. outline of back: *c*. a young shell: *d*. septal suture.
3 *a*. *Ammonites Kayei*: *b*. outline of back: *c*. septal suture.
4 *a*. *Ammonites Cala*: *b*. outline of back: *c*. septal suture.
5 *a*. *Ammonites Varuna*: *b*. outline of back: *c*. septal suture.
6 *a*. *Ammonites Rouyanus*: *b*. back view: *c*. septal suture.
7 *a*. *Ammonites Nera*: *b*. outline of back: *c*. septal suture.
8 *a*. *Ammonites diphylloides*: *b*. outline of back: *c*. septal suture.
9. Outline of the fragment of *Ammonites? indicus*.

Plate IX.

Fig. 1 *a*. *Ammonites Egertoni*: *b*. outline of back: *c*. septal suture.
2 *a*. *Ammonites Chrishna*: *b*. outline of back: *c*. septal suture.
3 *a*. *Belemnites? fibula* (a fragment): *b*. section.
4 *a*. Alveolus of a *Belemnites*: *b*. one of the septa showing the position of the siphuncle.
5 *a*. *Turrilites? planorbis*: *b*. view of the back.

Plate X.

Fig. 1 *a*. *Ammonites Menu*: *b*. outline of back: *c*. septal suture.
2 *a*. *Ammonites Sugata*: *b*. outline of back: *c*. septal suture.
3 *a*. *Ammonites Gaudama*: *b*. fragment showing the form of its back.
4 *a*. *Baculites vagina*: *b*. septal suture: *c*. section showing the surface of one of the chambers.
5 *a*. *Baculites teres*: *b*. section.
6 *a*. *Hamites undulatus*: *b*. section.
7 *a*. *Hamites nereis*, outline of a portion: *b*. section.
8. Specimen of *Hamites tenuisulcatus*, showing the form of its extremity, which is coiled in the manner of the genus *Helicoceras* of M. A. D'Orbigny. The outline is not a restoration, but represents a specimen in the collection. The surface of the coiled portion is abraded.

Plate XI.

Fig. 1 *a*. Outline of a portion of *Hamites large-sulcatus*: *b*. septal suture: *c*. section.
2 *a*. Outline of a portion of *Hamites rugatus*: *b*. septal suture: *c*. section.
3 *a*. Fragment of the posterior portion of *Hamites tenuisulcatus*, showing the curve: *b*. section of the same: *c*. part of the same species above the curved (*d*) section: *e*. part of a septal suture showing the bifurcated saddles.
4 *a*. Outline of a portion of *Hamites indicus*: *b*. septal suture, showing the bifurcated lobes and saddles: *c*. section.
5 *a*. Largest specimen (not entire) of *Ptychoceras sipho*: *b*. portion of a young specimen: *c*. one still younger: *d*. lateral, dorsal and ventral lobes of the chambers in the full-grown example: *e*, *f*, *g*. sections.
6 *a*. Outline of a portion of *Hamites subcompressus*: *b*. septal suture: *c*. section.
7 *a*. *Ammonites Indra*: *b*. outline of back: *c*. septal suture.

Plate XII.

Fig. 1. *Voluta pyriformis.*
2. *Voluta purpuriformis.*
3. *Voluta septemcostata.*
4. *Voluta muricata.*
5 *a*, *b*. *Voluta Camdeo.*
6. *Voluta cincta.*

Fig. 7. *Voluta breviplicata.*
8. *Voluta citharina.*
9. *Voluta radula.*
10 *a, b. Calyptræa elevata.*
11 *a, b. Calyptræa corrugata.*
12. *Natica obliquistriata.*
13. *Nerita oviformis.*
14. *Natica pagoda.*
15. *Natica munita.*
16 *a. Dentalium arcotinum*: *b.* section.
17. *Eulima antiqua.*
18. *Scalaria turbinata.*
19. *Pyrula pondicherriensis.*
20. *Cypræa Kayei.*
21. *Cypræa Newboldi.*
22. *Cypræa Cunliffei.*
23 *a, b. Oliva vetusta.*
24 *a, b. Tornatella labiosa.*
25. *Tornatella Curculio.*

Plate XIII.

Fig. 1. *Vermetus? Anguis.*
2. *Turritella monilifera.*
3. *Turritella ventricosa.*
4. *Turritella pondicherriensis.*
5 *a, b. Nerita ornata.*
6. *Cerithium sphæruliferum.*
7. *Cerithium scalaroideum.*
8. *Phasianella? incerta.*
9 *a, b. Trochus arcotensis.*
10 *a, b. Trochus rotelloides.*
11 *a. Trochus radiatulus*: *b.* magnified portion of the surface near the suture of the body-whorl, showing the radiating striæ.
12. *Trochus Rajah.*
13. *Pleurotomaria indica.*
14. *Triton? atavus.*
15 *a, b. Rostellaria palliata*: *c.* young shell.
16 *a. Strombus uncatus*: *b.* young shell.
17. *Rostellaria securifera.*
18. *Rostellaria cancellifera.*
19. *Murex fluctuosus.*
20. *Murex pondicherriensis.*

Plate XIV.

Fig. 1 *a*. *Cardita striata*: *b*. magnified portion of the surface.
2. *Arca abrupta.*
3. *Trigonia aliformis.*
4. *Mytilus typicus.*
5 *a*. *Pecten verdachellensis*: *b*. portion of its surface magnified.
6. *Gryphæa orientalis.*
7 *a*, *b*. *Natica rugosissima.*
8 *a*. *Pleurotomaria verdachellensis*: *b*. portion of the body-whorl magnified.
9 *a*. *Ammonites Buddha*, part of the body-whorl: *b*. portion of the back.
10 *a*. *Ammonites Sacya*: *b*. back view: *c*. portion of the dorsal surface magnified, showing the transverse striæ and the form of the varix.

Plate XV.

Fig. 1 *a*, *b*. *Natica suturalis.*
2 *a*. *Tornatella semen*, natural size: *b*. magnified portion of the surface of the body-whorl: *c*. outline of the columella, showing the two folds.
3. *Ringicula acuta*: *a*. magnified: *b*. natural size.
4 *a*. *Turritella Sowerbii*: *b*. magnified portion, showing the sculpture of a whorl.
5. *Voluta trinchinopolitensis.*
6 *a*, *b*. *Nerita compacta.*
7 *a*. *Murex trinchinopolitensis*: *b*. portion of the surface magnified.
8 *a*. *Dentalium? hamatum*: *b*. section.
9 *a*. *Strombus contortus*: *b*. the canal viewed from one side, showing its peculiar curvature.
10 *a*. Magnified figure of *Cerithium trinchinopolitense*: *b*. its natural size.
11. *Chemnitzia undosa.*
12. *Pyrula cancellata.*
13 *a*. *Cardium altum*, the full-grown shell: *b*. a young specimen: *c*. sculpture of the surface when decorticated.
14 *a*. *Poromya lata*: *b*. magnified portion of the surface.
15 *a*. *Cardium incomptum*, natural size: *b*. magnified.
16 *a*. *Arca trinchinopolitensis*: *b*. its hinge, beak and area.
17. *Mactra tripartita.*
18. *Psammobia inconspicua.*
19. *Venus arcotensis.*
20. *Venus analoga.*
21. *Venus eximia.*
22 *a*. *Pecten virgatus*: *b*. a portion of the surface magnified.
23 *a*. *Astarte planissima*: *b*. inner surface, showing the pallial and muscular impressions.
24. *Ostrea amorpha.*

Plate XVI.

Fig. 1 *a*, *b*. *Arca brahminica.*
2 *a*, *b*. *Arca japetica.*
3 *a*, *b*. *Arca Gamana.*
4 *a*. *Arca Clellandi*, natural size: *b*. magnified.
5 *a*, *b*. *Anatina arcuata*: *c*. young shell.
6. *Mytilus pulcher.*
7. *Mytilus cypris.*
8. *Mytilus nitens.*
9. *Mytilus flagellifer.*
10. *Pinna arata.*
11. *Avicula nitida.*

Plate XVII.

Fig. 1. *Gastrochæna semisulcata*: *a*. with its tube: *b*. the valves detached from the tube.
2 *a*. *Fistulana aspergilloides*: *b*. section.
3. *Solecurtus obscurus.*
4 *a*, *b*. *Panopæa orientalis.*
5 *a*, *b*. *Pholadomya connectans.*
6 *a*, *b*. *Poromya globulosa*: *c*. magnified portion of its surface.
7. *Lucina jugosa.*
8 *a*. *Lucina fallax*: *b*. young shell: *c*. cast.

Plate XVIII.

Fig. 1. *Spondylus subsquamosus.*
2 *a*. *Spondylus calcaratus*: *b*. young shell.
3. *Plicatula multicostata.*
4. *Plicatula septemcostata.*
5. *Ostrea pes-leonis.*
6. *Ostrea tegulanea.*
7. *Artemis lenticularis.*
8. *Cardium intersectum.*
9. *Trigonia semiculta.*
10. *Trigonia suborbicularis.*
11. *Trigonia orientalis.*
12 *a*. *Terebratula arabilis*: *b*. profile of a young specimen.
13 *a*. *Lima obliquistriata*: *b*. magnified portion of its surface.
14 *a*. *Corbula striatuloides*, natural size: *b*. magnified.
15. *Tellina pondicherriensis.*

Plate XIX.

Fig. 1. *Nucleolites elatus*: *a.* lateral view: *b.* anal extremity: *c.* one of the latero-dorsal ambulacra: *d.* oral ambulacra and parts about the mouth.
2 *a.* *Nucleolites Testudo*: *b.* profile.
3 *a.* *Nucleolites planatus*: *b.* profile.
4 *a.* *Holaster indicus*: *b.* profile.
5 *a.* *Brissus Rana*: *b.* profile.
6 *a.* *Brissus inæqualis*: *b.* profile.
7 *a.* *Brissus expansus*: *b.* profile of a smaller specimen.
8. *Ophiura Cunliffei.*
9 *a.* *Turbinolia arcotensis*: *b.* section of its summit.
10. *Cladacora*, sp.?
11. *Fungia filamentosa*: *a.* side-view: *b.* from above: *c.* base.
12. Carapace of a Crab.
13. *Ditrupa longissima.*

The President and Council regret to announce, that while these papers were passing through the press, they received intelligence of the death of Mr. Kaye, at Madras. They have thus to lament the loss to science of a young and accomplished Geologist, who, at the time of his death, was continuing those researches of which the papers now published contain the first results.

VI —*On the Geology of Southern Africa.*

By ANDREW GEDDES BAIN, Esq.

(*Communicated by the President.*)

[Read November 17th, 1852.]

PLATES XX.–XXVIII.

Introduction.

[Abridged.]

[BEFORE entering upon the special subject of his Memoir, Mr. Bain gives a sketch of the progress of his geological researches in South Africa, and refers to his former communication, laid before the Society in 1844*, descriptive of the Geology of the Eastern Provinces of the Cape Colony, which was accompanied by Professor Owen's description of the fossil remains of that peculiar reptile the DICYNODON.

Desirous of working out the history of this extraordinary creature and its habitat,—and further stimulated and encouraged by the grant of the Wollaston Donation Fund on the part of the Geological Society, and by a grant from the Royal Bounty Fund, through the hands of the late lamented Sir Robert Peel,—the author extended his researches, and sedulously applied himself to work out the geological phenomena of the Colonial territories through which he has now for some time been engaged in carrying out an extensive system of Military Roads.

As the basis for his operations, Mr. Bain has used the excellent Ordnance Map, compiled by Mr. Henry Hall of the Royal Engineer Department, and for a copy of which he was indebted to the kindness of the (late) Honourable Mr. Montagu, Secretary to Government, and of Charles Bell, Esq., Surveyor-General of Cape Colony.

Before explaining the details of the Geological Map now laid before the Society, Mr. Bain ventures to claim the indulgence of geologists for such imperfections as may be found to exist in the work he now submits to their consideration, and begs to remind the Society that, not only were the operations on which his observations are founded carried on, for the most part, in an uncivilized and dangerous

* Vide *supra*, p. 53 *et seq.*

region, but that the map, such as it is, is the result of the labours of a self-taught individual, thirty-six years of whose life have been spent in the arid wastes of Southern Africa, entirely cut off from participation in the advantages of a civilized country; and the results of his labours, consisting of a Geological Map of South Africa, with three general, and five local Sections, nineteen cases of fossil remains, transmitted in 1847, and four cases of fossils*, now sent, the author respectfully offers for the acceptance of the Geological Society of London. Another extensive collection, made on the Caledon and Orange Rivers, was unfortunately lost amidst the turmoils of the Kaffir war.

The author proceeds to describe the different Rock-formations of the Colony, as they present themselves along the lines of the several Sections (see Plate XXI.); reserving, however, the consideration of the extensive Reptiliferous deposits, presented in the southern portion of each section, until the other formations have been treated of. The general arrangement and relations of the formations here referred to are exhibited in the diagram at page 178.]

[The following list of authors comprises, first, several of the travellers who have more especially noticed the geological structure of the Cape and of other parts of South Africa; and, secondly, the geologists who have supplied more definite information on the rocks and fossils of that region:—

1801. J. Barrow. An Account of Travels into the Interior of Southern Africa, in the years 1797 and 1798. 4° London, 1801.

1810. In Wilson's 'History of Mountains' (4° London), vol. iii. pp. 727–748, will be found a full *résumé* of the geological facts noticed in Barrow's 'Travels in Southern Africa,' above alluded to, and other older works relating to Cape Town and its vicinity.

1812. H. Lichtenstein. Travels in Southern Africa in 1803 and 1806. (Translated by A. Plumptre.) 4° London, 1812.

1818. C. J. Latrobe. Journal of a Visit to South Africa in 1815 and 1816. 4° London, 1818.

1819. Clarke Abel. Narrative of a Journey in the Interior of China, and of a Voyage to and from that Country in the years 1816 and 1817 (p. 285, &c. Table Mountain, &c.). 4° London, 1819.

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* Of the extensive suite of specimens here referred to, the fine collection of reptilian remains, with the rock-specimens and a series of the tertiary, secondary, and palæozoic fossils, have been transferred to the British Museum; and another series of the fossils has been placed in the Museum of Practical Geology. The description of the palæozoic and secondary fossils has been kindly undertaken by Mr. D. Sharpe and Mr. Salter, whose communications on the subject follow Mr. Bain's paper; and we may soon look for detailed accounts of some at least of the reptilian remains from the pen of Prof. Owen.—Ed.

1822. W. J. Burchell. Travels in the Interior of Southern Africa. 2 vols. 4° 1822–4.

1844. J. Backhouse. A Narrative of a Visit to the Mauritius and South Africa. 8° London and York, 1844.

1813. Professor Playfair. Account of the Structure of the Table Mountain and other parts of the Peninsula of the Cape; from observations made by Capt. Basil Hall. Trans. Roy. Soc. Edinburgh, vol. vii. p. 270.

1818. Capt. D. Carmichael. On the Geological Structure of part of the Cape of Good Hope. Trans. Geol. Soc. vol. v. p. 614.

1837. J. F. L. Hausmann. Beyträge zur Kunde der geognostischen Constitution von Süd Africa. Göttingische gelehrte Anzeigen, 1837, pp. 1449–1462.

1839. In the 'Silurian System,' p. 583, Sir Roderick Murchison alludes to several collections of fossils from South Africa.

1841. W. B. Clarke. On the Geological Phænomena in the Vicinity of Cape Town, South Africa. Proceed. Geol. Soc. vol. iii. p. 418. (Original drawings illustrative of lithological details of the structure of Table Mountain, and having reference to Mr. Clarke's paper, are in the Society's Portfolios.)

1844. C. Darwin. Volcanic Islands, &c. p. 148, &c. (Granite and Sandstone of the Cape.)

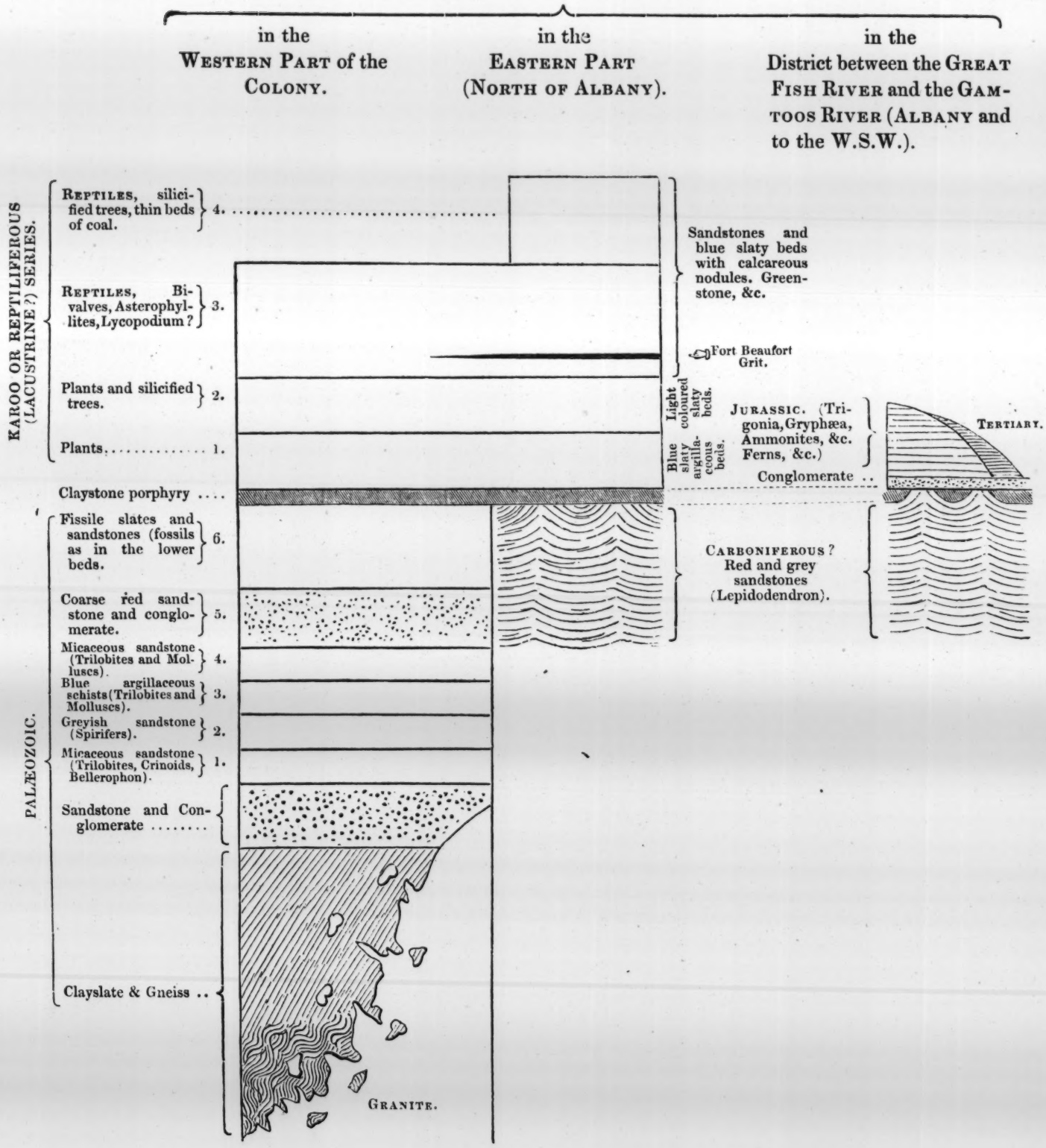
1845. A. G. Bain. On the Discovery of the Fossil Remains of Bidental and other Reptiles in South Africa. Trans. Geol. Soc. 2 ser. vol. vii. pp. 53–59.

1845. Prof. Owen. Report on the Reptilian Fossils of South Africa. Trans. Geol. Soc. 2 ser. vol. vii. pp. 59–84.

1850. Dr. Fr. Krauss. Ueber einige Petrefacten aus der untern Kreide des Kaplandes. Nova Acta C. L. C. Nat. Cur. vol. xxii. part 2. pp. 439–464 (plates); and Quart. Journ. Geol. Soc. vol. vii. part 2. Miscell. pp. 120–122.

1852. Dr. F. Sandberger. Ueber einige paläozoische Versteinerungen des Cap-landes. Leonhard and Bronn's N. Jahrb. für Min. &c. 1852, pp. 581–585; and Quart. Journ. Geol. Soc. vol. ix. part 2. Miscell. pp. 1–4.]

DIAGRAM OF THE STRATA



Section No. 1. (Plate XXI.)—*From the back of Table Mountain to the Middle Roggeveld.*

In this section *granite* is the fundamental rock, though the superincumbent gneiss and clayslate, as will afterwards be shown, are the oldest. It forms the basis of the celebrated Table Mountain and Lion's Head at Cape Town, and in those localities is, generally speaking, coarse-grained, and frequently porphyritic.

At the Paarl and in the neighbourhood of Bain's Kloof it often assumes a binary form, the mica being there wanting, and is everywhere traversed by veins of quartz and felspar; whereas at George, where this rock also appears, the mica seems to predominate and is in very large flakes. The granite is also found there in a porphyritic form.

At the foot of Table Mountain and at Bain's Kloof are extensive beds of a decomposed granite, sometimes attaining a thickness of from 50 to 60 feet; the angles of its component minerals are frequently rounded, and masses of sandstone from the mountains above are sometimes found imbedded in it; and, though it is so soft in some places as to be cut with a pickaxe or spade, yet distinct veins of quartz running through it can be traced in all directions: when it passes into the real granite, the line of junction can never be traced.

Granite, I am told, is also to be found in the neighbourhood of Port Natal; but I did not observe any when I was in that country. It is also said to appear in considerable masses at the Kamies Berg and the Bushman Karoo Flats; but I have not laid it down on the Map in those parts, as I do not know its extent.

I am not aware that any of the precious or other metals have ever been discovered in this rock in South Africa; but at the Lion's Head I found crystals of tourmaline and a small bed of kaolin.

In Europe, granite is generally found in the most elevated countries, as in the Alps, Pyrenees, &c.; but in South Africa, on the contrary, it invariably assumes a perfectly subordinate character, nowhere showing any elevated peaks, lofty *aiguilles*, or serrated ridges*. The Paarl Mountain and the Paardeberg are the most prominent of their class; but neither of them exceed the height of 1500 feet, and in the neighbourhood of the lofty sedimentary mountains appear but small hillocks in comparison. When I first saw the granitic formations in the district of George, I mistook them for tertiary rocks, from their soft rounded appearance, until a section in one of the rivers undeceived me. We next come to the

* Since writing the above, I hear from my talented friend T. Maclean, Esq., that Kamies Berg and Lely Fontein are exceptions to this rule.

Gneiss,

which never occurs but in contiguity with the granite; for it seems always to pass into clayslate when beyond the influence of the plutonic rock below. Section No. 4, Pl. XXI., shows the invasion of the latter on the ancient sedimentary deposits, where its veins are seen to penetrate the laminated rocks, whilst huge detached masses of granite are entangled in the gneiss, and fragments of gneiss remain isolated in the granite.

Gneiss occurs at Platte Klip at the foot of Table Mountain, Hottentots Holland, and near Little Brak River in the district of George. I consider it to be contemporaneous with the

Clayslate,

which is very extensively developed both in the southern and western parts of the colony, and is of great thickness. This formation contains rocks of various kinds, and presents a great diversity of aspects. At Cape Town extensive quarries are worked in it for building-purposes, and at Robben Island, in Table Bay, the rock is cut into square flags for pavements, grave-stones, &c., taking a smooth face and cutting very freely. It is there of a bluish-black colour, but is devoid of slaty cleavage, as are, I believe, all the other schists of the colony. In many parts it passes into mica-slate, as at Swartland, Tulbagh, Slaryhoek, Worcester, and many other parts. In some places it is completely decomposed into a soft clay, of various colours,—yellow, blue, pink, white, and brown, as at Bain's Kloof, where, in a tunnel which I perforated, through a thickness of 400 feet, I never required even the aid of a crowbar in the excavations (except through some massive quartz-veins), the whole being worked by the pickaxe and spade.

The clayslate, like the granite, never rises to any great height; but is generally found to constitute all the valleys of elevation in the western and southern parts of the colony, extending as far east as Gamtoos River.

The laminæ or strata, when visible, are always at high angles, frequently vertical and contorted, and often entirely overturned, having evidently suffered much from lateral compression. It is quite impossible to calculate the thickness of the clayslate. I have made many extensive excavations in these rocks, but never saw the least sign of a fossil in them. Hence I conclude that they are non-fossiliferous. Numerous quartz-veins traverse them in all directions. Their strike, like that of all the older rocks, is generally from S.E. and N.W. to E.S.E and N.N.W.; and, as far as my researches go, they are destitute both of metals and minerals.

Lying unconformably on the clayslate is a formation of great thickness and extent, which, from its geological position, though not at all from its physical attributes, I consider to be the equivalent of

The Lower Silurian.*

This is also widely developed; it consists of unfossiliferous sandstone and conglomerate, and forms the summits of Table Mountain and Lion's Head, as well as that of all the extensive and lofty ranges of the western and southern parts of the colony.

A very good description of it has been given, as far as it refers to the neighbourhood of Cape Town, in Clarke Abel's Travels, p. 295, to which I may with confidence refer. But I must at the same time observe that the imbedded pebbles very much decrease in numbers in an easterly direction, but increase as the range trends northerly; for at Pikeneers Kloof and Rinoster Hoek the whole mountain seems to be one mass of conglomerate, many of the imbedded stones being larger than a man's fist.

Those imbedded stones and pebbles being principally composed of clayslate and quartz, it becomes a matter of interesting speculation as to the district whence they were derived. No antecedent quartzose rock (excepting the quartz-veins in the clayslate) at present exists in South Africa; hence we must conclude that the parent of those numerous pebbles and conglomerates now lies buried in the depths of the Atlantic or Indian Oceans.

When this sandstone is seen to rest on the granite, as it does at Lion's Head (see Section 4) and at Du Zoits Kloof, it is evident that the granite had cooled down and was perfectly quiescent at the time of the deposition of the former; showing a very marked difference between the junction of the gneiss with the granite, and of the latter with the sandstone,—both of which are shown in this section.

The thickness of this formation it is difficult to ascertain; but, as far as I have been enabled to estimate it, it cannot be less than from 10,000 to 12,000 feet; so that, if Table Mountain was ever covered with a like thickness of deposit, which I have no doubt it was, and had retained it until the present day, then it would eclipse the Peak of Teneriffe, or even rival Mont Blanc in altitude.

To the advocates for the sudden upheaval of mountains, I think the removal of such a mass from the top of Table Mountain presents a considerable difficulty: but, compared to the immense denudation that has taken place in this formation on the Cape Flats alone, to say nothing of the extensive valleys of elevation leading from Tulbagh by Worcester, Swellendam, and George, and from Bain's Kloof to Picket Berg and Donkin's Bay, it is a mere nothing. A glance at Section

* The author's nomenclature is here retained: the probable geological age assigned by Mr. D. Sharpe and Mr. Salter to the fossiliferous rocks immediately overlying this sandstone will be seen in subsequent pages to be "Devonian."—Ed.

No. 1, from the top of Table Mountain to that of the high mountain at Michell's Pass, will give some faint idea of the magnitude of this denudation; for there cannot be the smallest doubt that those two mountains were at one time connected.

It appears to me that no agent with which we are acquainted could have effected this immense degradation and the complete removal of the fragments but the tides and marine currents, as the mountains slowly emerged from the bosom of the primeval ocean, and that too probably before the rocks had attained their present tenacity of consistence. Not a fragment of this sandstone is now to be found on the flats or plains at any distance from the mountains, except here and there small portions *in situ*, resting unconformably on the clayslate, just sufficient to attest that the whole had at one time been continuous.

This formation extends from Donkin's Bay, on the west coast, to Cape St. Francis, on the east, including all the high mountains of the Cape peninsula and Hottentots Holland; and, from the extensive excavations I have made in it, I think I can safely say that it contains no fossils. The only minerals I have discovered are iron-pyrites and some oxides of iron of no value.

Leaving the quartzose sandstone, I shall proceed briefly to describe the South African

*Upper Silurian Rocks**,

where the first signs of primeval life begin to appear. Many specimens of the fossils of this series have at various times found their way to Europe; but, as far as I am aware, no attempt has ever been made to show their position among the South African formations, which I shall now endeavour to do, however imperfectly.

This Upper Silurian formation can be well traced in the Warm and Cold Bokkevelden, where it rests conformably on the above-described sandstones, and where its lowest strata contrast wonderfully with the rough gritty sandstone beds on which they repose. They consist principally of soft micaceous deposits, of various colours, abounding in small Trilobites, Crinoids, and Brachiopods, the fossils being frequently enclosed in small rounded nodules. Higher up in the series, the rocks are composed of a greyish sandstone containing numerous casts of Spirifers, which, from a fancied resemblance to the Butterfly, the Boers call *Schoelappers*.

Next are found compact, blue, argillaceous schists, easily disintegrating when exposed to the sun, and abounding in Trilobites of a larger size, *Conularia*, Brachiopods, and other Mollusks. This subdivision is overlaid by a deposit resembling the lowest micaceous beds, but containing a much greater variety of Mollusks, as well as many specimens of the heads, bodies, and tails of a large

* See previous Note at p. 181.

species of *Homalonotus**. They are remarkable *Trilobites* with a hooked beak in front; hence I provisionally named them the "*hawksbill.*"

The next rock in superposition is a coarse red sandstone, of great thickness, containing numerous imbedded quartz-pebbles, much resembling the older sandstones of the Cape, and, like them, containing no fossils, as far as my researches go. It is this rock which forms the elevated ranges of the Cedar Berg, Swarteberg, and Cold Bokkeveld mountains, attaining in some parts an elevation of 6840 feet above the sea. Its contortions and flexures are such (see Section No. 5, Plate XXI.) as to bid defiance to any calculation of its thickness.

On the flanks of those mountains is an extensive deposit, principally of fissile slates and sandstones, geologically higher, though locally lower, extending far into the Karoo, and containing many fossils of a similar nature to those already described. These beds are the last and uppermost of the Upper Silurian series†, as developed in this country, and they disappear here under the zone of igneous rocks marked blue in the Map and Section, and which everywhere divides the palæozoic from the later and more northerly strata.

I have not yet discovered a vestige of limestone, marble, or corals in these deposits. The Crinoids seem to have been plentiful enough, but are never found in a perfect state. The finest I ever saw crumbled to pieces in my endeavours to extract it from the rock, so that I can show no better specimens than a few detached ossicles or joints.

The further description of this line of Section, with its extensive Reptiliferous strata, I shall leave (as stated at p. 176) until I have first described all the other formations.

Section No. 2. (Plate XXI.)—*From near Cape Recife to Lower Zeekoe River.*

The fundamental rock of all the country stretching from Gamtoos River to the Great Fish River, and bounded to the northward by the Bothus Hill and Zuurberg Ranges, appears to be that of our

Carboniferous Formation,

which lithologically differs but little from the quartzose sandstones of the Silurian (?) ranges of the western parts of the colony (except that the carboniferous rocks have no imbedded pebbles). This appearance led to a mistake on my part in the description given in my letter of April 1844 (see above, p. 54), where I classed them all as

* The *H. Herschelii*, of Murchison.

† It was to this fossiliferous palæozoic series, here termed "Upper Silurian," that Prof. E. Forbes alluded at the British Association Meeting in 1851 (Report of Sections, p. 58), when he called attention to the discovery of "Devonian" rocks in Fezzan by Dr. Overweg, and in the Cape Region, as above described.—Ed.

belonging to the carboniferous system, but which opinion subsequent researches have proved to be erroneous: otherwise I believe that description to be perfectly correct, and to which I would now refer. The quartzose sandstone, which is the general characteristic of this formation, passes into chloritic schist at De Stade's and Van Staaden's Rivers, where rich mines of galena and copper-ore have been lately successfully worked*.

No workable coal has yet been discovered in this formation; but I am told that numerous species of carboniferous plants† have lately been found near the Kowie River in the talcose schist.

The next rock in superposition is a *claystone porphyry*; but the description of this I shall defer for the present. Upon it rests a coarse

Conglomerate,

which has also been described in my former communication. It is here seen on the flank of the Zuurberg, and portions of it appear in Section No. 3, at Grobbelar's Kloof, near Graham's Town; also at Lange Kloof, and other parts of the district of George.

Reposing conformably on this conglomerate is an exceedingly interesting group of rocks, which I have ventured to call the

Lias (?),

from the prevalence of a characteristic liassic fossil, the *Gryphæa incurva*‡. This deposit does not seem to be anywhere extensively developed; but, as a glance at the map will show, occupies only small indentations of the coast about the estuaries of our largest rivers. I know that more of these deposits than I have laid down exist along the coast, especially in Kafirland; but, not being sufficiently acquainted with them, I have not given them a place in the map.

I shall not attempt to describe the various fossil treasures of this highly interesting formation; suffice it to say, that whole forests of calcified trees, of large size, are found in the neighbourhood of Sunday's and Bushman's Rivers, in a most perfect state of preservation, imbedded horizontally in the rock. Ferns, Zamias, and fragments of wood in a lignitic state, occur mixed up with fragments of gypsum and Reptilian bones, together with marine exuviæ—*Trigonia*, *Ammonites*,

* Copper-ores are also found in Namaqualand in chloritic rocks; but the mines cannot be worked to advantage, on account of the scarcity of water and fuel.

† A specimen of micaceous schistose rock with Lepidodendron-like impressions, from Kowie River, is in the Society's Museum.—Ed.

‡ This fossil, although very similar to the species above referred to, is an *Exogyra* (*E. imbricata*, Krauss). The formation in question, however, is probably referable to the lower jurassic or lias series on other fossil evidence: see Mr. D. Sharpe's paper in the sequel.—Ed.

and various other Mollusks, giving the formation, on the whole, perhaps more of an oolitic than a liassic character*.

Resting unconformably on the lias (?) and the older rocks along the coast, are several

Tertiary Formations,

principally of white calcareous rock, which I shall not attempt to describe, as I can neither correctly lay down their boundaries, nor has my experience among them qualified me to enter into particulars. They are probably of the Pliocene age, as they contain many specimens of Mollusks at present inhabiting the neighbouring seas. My collection contains a few specimens, principally from the eastern province, and one from Mossel Bay.

Having now briefly described the rock-formations in the more southerly portions of the Sections Nos. 1 and 2, I shall pass over that part of No. 3 (Plate XXI.) which contains what has been already described until we reach the

Claystone Porphyry,

a description of which I attempted in my paper before referred to (*supra*, p. 54), as far as I then knew it to extend, viz. from the mouth of the Gualana River in Kafirland to the Little Fish River in the Division of Somerset, a distance of eighty miles. I little dreamt then of its enormous extent, or to what important conclusions it would lead, for I have since traced it (with the exception of a small tract of country which I have had no opportunity of exploring, but through which I have no doubt it is continuous all the way, as above described) from the Gualana Mouth, behind the Zuurbergen and further along, and running nearly parallel to the Great Swartberg, Witteberg, and Cedarberg ranges, up to where my researches terminate, in a north-west direction as far as Hantam in the Clan William Division; a distance of nearly 600 miles. How much farther it may extend is a problem for future geologists to solve.

This enormous igneous mass, as will be seen by the map and sections, rests on the carboniferous rocks in the eastern province, and in the western parts on the flanks of our Upper Silurian (?) ranges, running, like the mountain chains, generally

* In 1851 Col. Portlock exhibited to the Meeting of the British Association at Ipswich a series of fossils collected by Mr. R. Rubidge at Sunday River; and observed that they comprised *Ammonites*, *Gryphæa*, *Pholadomya*, and *Trigonia*; together with plants of the genera *Zamia*, *Neuropteris*, *Pecopteris*, and *Sphenopteris*. "The shells were apparently of Jurassic age; the plants had been examined by Dr. Harvey, and the species of *Neuropteris*, *Pecopteris*, and *Sphenopteris* were regarded as chiefly resembling those of the coal of Australia; whilst the presence of the genus *Zamia* in abundance impresses an oolitic aspect on the flora." Report Brit. Assoc. 1851, Sect. p. 68. [From a late communication from Mr. Rubidge, it appears doubtful whether some of the *plants* here alluded to were not derived from the Karoo series on the eastern side of the Stormberg.]—Ed.

nearly parallel to the coast. There can be no doubt that its former horizontal extent was much greater than at present, for we find detached masses of it to the south of Governor's Kop and Zuurberg (see Sections No. 3 and 2), and in the Cold Bokkeveld (see Section No. 1), having, according to my idea, covered all those immense mountain-masses before the period of their upheaval. I have no doubt also that many detached portions will be found to the south of the Great Swartberg chain; but my acquaintance with that part of the country is too limited to enable me to point them out.

In what manner could this extensive mass of igneous matter have been poured out on the surface of the earth, whose northern limit perhaps extends thousands of miles in the interior, and whose eastern termination must for ever remain a mystery? In vain have I searched for dykes, as the channels of eruption, such as are so plainly visible in the other trap-rocks of the country. It is true, that at its junction with the carboniferous schists in Albany the strata are frequently vertical, and even overlie the porphyry, and are much altered by heat (see Catalogue of Rocks of Section No. 3, specimen No. 14, marked A in the section), giving the latter the appearance of being the upheaving rocks. At Ecca Valley, however (marked B in Section No. 3), at Pluto's Vale, and at Hantam, the opposite extreme, the reptiliferous beds rest conformably on the igneous rock, and no indications of heat are exhibited by those slates (as the specimens in the collection will show), the porphyry having evidently cooled before the deposition of the former; consequently this great zone of igneous rock cannot be an immense dyke, as might otherwise be supposed.

From the numerous imbedded pebbles of granite, sandstone, quartz, and clay-slate, apparently not altered by heat, one might be led to believe that the whole was an aqueous deposit; but after inspecting the magnificent amorphous masses of hundreds of feet in height, as seen at Pluto's Vale in Albany, Toverberg in the Western Karoo, and at Klip Rug in Hantam, with many other splendid sections, where not the smallest sign of stratification appears, that idea also falls to the ground.

In this dilemma, I trust, I may not be considered visionary if I attribute the whole to the production of an immense volcano, which we may suppose to have existed somewhere near the junction of the Vaal and Orange Rivers, or perhaps about the site of the present Compass Berg, whose peak rises to the height of 10,000 feet above the sea-level; and thence deluged with fiery billows the Silurian (?) plains, and spread ruin and desolation over the carboniferous forests for tens of thousands of square miles.

Besides the imbedded pebbles, &c., above mentioned, I found at one place, near Zout Kloof in the Karoo, a great number of rounded calcareous nodules imbedded in this rock, from 3 inches to a foot in diameter, some of them being perfectly

spherical, and resembling cannon-balls or bomb-shells; these balls I have never found in any other locality.

Having now described the claystone-porphyry along its whole line, I shall return to Section No. 1, where I have already entered on that part of the colony known as the Great Karoo Desert, which, from the Praam Berg, in Hantam, to the Sunday's River, in Graaff Reinet Division, scarcely contains the permanent residence of a dozen families. It may be considered altogether as a great hill-studded plain, bounded on the west by the Cedar Berg and Swart Rug, and on the south by the Witte Berg, Great Swarte Berg, and Blauw Berg, very prominent mountain-ranges. The elevated plateaux of Hantam, Roggeveld, Nieuwveld, and Snieuw Berg form its inland boundaries. In the summer, with the few exceptions above mentioned, it is quite uninhabited, being a perfectly arid desert; but the autumnal rains cause the vegetation to spring forth so rapidly, that in the course of a few days it is (as if by magic) suddenly converted into a perfect flower-garden, and yields abundant herbage for cattle and sheep, so that all the Boers from the surrounding highlands descend to the plains below during the winter months, living in tents, surrounded by their families, flocks, and herds in true patriarchal simplicity.

This immense desert, as well as the whole tract coloured by different shades of green in the Map (Plate XX.), would appear from geological evidence to have been once occupied by an enormous lake or sea. The fauna and flora of this perhaps isolated inland sea are now represented by the plant-remains buried in its finely laminated deposits, and by the singular family of Dicynodonts and other peculiar ancient reptiles, who here sported about in a world of their own.

I shall now proceed briefly to describe these *Reptiliferous strata.*

The first or lowest deposit is a finely-laminated, blue, argillaceous rock, being invariably the same all along the margin, from Hantam to the Great Fish River, reposing conformably on the claystone-porphyry, and quite unaltered by heat. A narrow band of soft white slaty rock succeeds to this, which is succeeded by an extensive bed similar to the first, but containing abundance of plant-remains*.

The only fault I have ever discovered in this country is found among those slaty beds where they begin to alternate with sandstones at Buffels River, as shown in Section 7 (Plate XXI.). Near this part also the rocks are very much contorted, which does not appear to be the case where the three general sections pass through the reptiliferous strata.

In my communication of 1844, before the idea struck me of the lacustrine origin of these rocks, I have already described the other divisions of the formation, which

* The specimens from the Ecca Valley, in the collection of 1847, and a large stem of a plant found at Potatas River, in the Western Karoo, now sent, will illustrate this part of the section.

I need not here repeat, as the specimens in my collection of 1847 will illustrate the whole, there being no difference in all the three sections traversing the reptiliferous series.

I ought, however, to add, that I discovered a number of fossil plants (Pl. XXVIII. fig. 1) in the Middle Roggeveld, which I have not met with in the more eastern sections, and two specimens of which I send with my present collection. These occur in the sandstone and schistose strata of that locality to the thickness of 1200 feet. They somewhat resemble the *Asterophyllites* of the coal-measures, and, like the *Sphagnum palustre* of the peat-bogs, seem to have thrown out fresh branches as the lower parts became enveloped in mud. I arrived at this conclusion by finding the plants invariably in a vertical position, and the stalk passing through several distinct beds of stratification, with something at the bottom resembling roots.

Among the fossil plants of Roggeveld, a species of *Lycopodium*? was frequently recognized, but could not be extracted from the rock. At Little Table Mountain, Kleine Roggeveld, I discovered the silicified stem of a large tree about 20 feet long, and in a very perfect state of preservation.

Towards the northern end of Section No. 3, I discovered in 1846 an extensive tract of country which, in addition to the remains of Dicynodonts and other reptiles, contained great masses of siliceous wood, imbedded in its horizontally stratified white sandstones, together with thin beds of coal. None of the coal-beds, of a quality fit for use, were thick enough to be worked. It is frequently anthracitic, and much of it is deficient in bitumen.

At Wittebergen, near the upper branches of the Orange River, I found a large sandstone slab, of about 8 feet square, with the branch of a tree imbedded therein, in all its beautiful and extensive ramifications, just as it grew, the wood having completely partaken of the nature of its siliceous matrix; it was, however, impossible to remove this splendid fossil.

A remarkable feature in the geology of South Africa is the immense numbers of

Trap Dikes

that reticulate throughout the whole of the reptiliferous strata; their erupted matter, on reaching the surface, being generally found capping the highest mountains, with huge irregular prismatic columns. The most wonderful of these dikes is that gigantic mass which protrudes from the Spitzkop, as seen in Section No. 2, Plate XXI., and rises to the height of 10,000 feet above the sea. The horizontality of the stratified rocks is never in the least disturbed by the intrusion of the trap; nor are faults, as in Europe, produced by this cause: the only difference it makes is in indurating or honeycombing the strata through which it passes. At Spitzkop, above mentioned, the sandstone in contact with the huge dike is meta-

morphosed for a distance of 40 or 50 yards, and sometimes converted into perfect hexagonal columns. The slaty rocks likewise, which are within its influence, from being of a dark blue colour, have been changed to black, much resembling in appearance fine-grained basalt. There are many smaller dikes in various parts of the country, protruding through the sandstone in a similar manner, and shaped like the Spitzkop. These also, being harder than the horizontal strata, have longer withstood the action of the elements, which have disintegrated and worn away the softer sedimentary deposits.

I have endeavoured to show some of the principal dikes in the sections, but have not attempted it in the map; for, without a proper survey of the whole country, even an approximation to the truth could not be attained, as the dikes appear to run in every direction, forming an irregular network, which would only disfigure the map, and look like a confused mass of roads*.

Having now briefly, though very imperfectly, sketched the different formations of South Africa, and to the best of my ability laid down the same on my map and sections (Pl. XX. XXI.) in such a manner as, I trust, will be intelligible, it will be seen that I have been so far successful in tracing at least a part of the Dicynodon's habitat, with that of the other wonderful reptiles with remains of which my collections abound. The existence of a great lake or inland sea, occupying the major part of the South African promontory, was never once dreamt of by me when I first discovered those singular relics, but subsequent researches have convinced me that such was the case, and moreover that the period of its existence was shortly after the deposition of what I have called in this sketch the "Carboniferous formation," the "claystone-porphyry" only intervening between it and the Reptiliferous deposits. I have arrived at the conclusion of the lacustrine origin of this extensive area from the fol.owing facts, viz. :—

1st. The general uniformity and homogeneity of the deposits.

2nd. The great abundance of fossil wood, and the similarity of the vegetable remains found throughout the range of these beds.

3rd. The large quantity of freshwater plants traversing the strata in the vertical position on the spot where they grew.

4th. The peculiar characters of the reptiles found fossil in these strata, and unknown elsewhere.

5th. The general absence of marine exuviæ, and the presence of small freshwater shells†.

* See also Capt. Charters's observations on the vast extent of greenstone in South Africa, Proc. Geol. Soc. vol. iii. p. 102.—Ed.

† Mr. Bain's collection does not afford certain evidence on this point. A piece of rock with minute

In my former communication of 1844, so frequently alluded to, I offered some conjectures as to the probable age of the Reptiliferous strata, being in a great measure misled in the opinion then offered by having received an *Ammonites planulatus*, *said* to have been found *in situ* by the donor at the foot of the Spitzkop; circumstances which I need not here relate, coupled with a subsequent better acquaintance of that elevated part of the country, led to the discovery that this was quite a mistake,—the fossil having been brought from Europe. Professor Owen appears to consider the Bidental Reptiles to be of the age of the New Red Sandstone; and, from extensive researches made among the Reptiliferous strata since the transmission of my first collection to England, at which time I erroneously assigned to them an Oolitic origin, I now perfectly concur with the learned Professor, that they are at least as old as, if not older than the New Red period.

I have in my possession a fine specimen of the *heterocercal* tail of a fish, found at Styl Krantz in the upper Reptiliferous slates; and I have seen various other ichthyolites of a similar description, found near Fort Beaufort in the lowest part of the same formation;—and perhaps, from the presumed palæozoic character of such fish-remains, we may find another argument in favour of the inference that these beds are at least as old as the New Red Sandstone.

But I am inclined to assign to them even an older date. Although I have classed my "Carboniferous formation" among the marine formations, yet I am by no means certain that they are such, for no marine exuviæ, as far as I am aware, have ever been discovered in them. Lithologically they differ much from the Carboniferous series of Europe, but I think they are their true African equivalents; and the great resemblance between their fossil flora and that of my "lacustrine" deposits which contain such extensive beds of coal, even in their upper parts, irresistibly lead me to the conclusion that they are also nearly related to the Carboniferous series, and hence that the Dicynodon, with its numerous and wonderful congeners, are amongst the oldest of reptiles.

Before concluding, I shall offer a few general remarks on the *Superficial deposits* of South Africa.

Very extensive deposits of calcareous Tufa are found along the coast (see Section No. 4); these are composed principally of the detritus of the Tertiary formations, which I have no doubt at a former period everywhere fringed the

shells, some of which may have been estuarine (see Pl. XXVIII. figs. 8–25), was said doubtfully to have come from Snieuwberg, but it is a part of the lowest Zwartkop rock. Another rock with casts of minute (Cyclas-like) shells is unfortunately without a label, and may correspond to some specimens from Kat River referred to in Mr. Bain's MS. Catalogue: if so, it might have aided the author's arguments.

The freshwater fossils from near Graaf Reinet (Pl. XXVIII. figs. 2–7), in the Society's collection, constitute at present all the direct evidence we have on this point.—Ed.

coast. In some places it attains a thickness of upwards of 100 feet, and contains imbedded shells of the common land-snail in great abundance, as well as various recent animal and vegetable remains*. At Cape Agulhas the new lighthouse has been built of this rock, but it is generally used merely for lime-burning.

Thin beds of calcareous tufa are also found overlying the Reptiliferous strata in all parts of the interior, and are invariably used by the inhabitants for lime, there being no regular stratified limestones in South Africa.

The Cango Caverns† in the Division of George are famous for their large and beautiful stalactites and stalagmites, which afford a very pure carbonate of lime, much superior to the tufas. Smaller caves of the same are found in different parts of the colony.

Frequently, resting on the above or on the older rocks below, are found beds of recent marine shells exactly the same as those at present inhabiting the Indian and Atlantic Oceans,—some specimens accompany my collection of 1847. I have found them near the mouth of the Great Fish River, Kowie, Port Elizabeth, Van Staaden's River, Mossel Bay, and Lion's Head, Cape Town (see Section, No. 4); and they are also to be seen all along our western coast. In some parts they occur in beds of considerable thickness, imbedded in loose sand mixed up with bones of recent land-animals, and even many specimens of native pottery and other works of man; so that this raised beach, for such it must be, has been uplifted to its present height during the historical period. Its height varies from 20 to 300 feet above the sea-level‡.

A superficial ferruginous deposit, which is found in the greatest abundance on the Cape Flats, and there covering the clayslate, consists of an oxide of iron, derived either from the clayslates themselves or from the neighbouring sandstone mountains§. In some places it reaches the thickness of 10 feet, and is much used for road-purposes. This ironstone is found in small patches on many of the marine formations throughout the colony. At Kalga Springs, near Port Elizabeth, it is curious to observe the ferruginous deposits forming and indurating, as it were, before our eyes, as the water charged with the iron flows away from the source; this is illustrated by some specimens in my collection of 1847.

Hot, tepid, and cold chalybeate springs are found in various parts of the colony, and are much resorted to by the inhabitants as a cure for all diseases. None of

* See also Capt. Nelson's observations on the "Æolian" beds at Algoa Bay, Quart. Journ. Geol. Soc. vol. ix. p. 206, note.—Ed.

† For a detailed description and illustration of these Caverns see G. Thompson's 'Travels in Southern Africa,' vol. i. p. 275, &c. 1827, 8vo. 2 vols.—Ed.

‡ See also the Rev. Mr. Clarke's Observations, Proc. Geol. Soc. vol. iii. p. 420.—Ed.

§ See also Mr. Darwin's Observations, 'Volcanic Islands,' p. 143.—Ed.

them appear to be of volcanic origin, the existence of true volcanic rocks being unknown in this country.

On the Cape Flats, near Tygerberg, I discovered in 1846 a small bed of white sandstone, resting unconformably on the clayslate, and containing beautiful casts or impressions of what I took to be fucoids. My late talented friend Col. Michell, our former Surveyor-General, kindly took home some specimens, which he presented to the Society in my name.

The Rev. Dr. Adamson, now in England, informed me last year that he had, some time ago, discovered in the neighbourhood of Wynberg, some stalk-like bodies in a small bed of white sandstone, also resting on the clayslate, perhaps of the same age as the Fucoidal bodies above mentioned. Some specimens which he showed me were very obscure. My present collection contains a specimen of what resembles a Calamite (?), which I got at Buffeljugts River, near Swellendam, also in white sandstone, lying on the clayslate*.

I ought perhaps also to mention that I have frequently heard of animal remains being discovered in the alluvium, differing from those of existing animals; and I discovered at Bloemhoff in the Division of Graaf Reinet, about 10 feet below the surface, in a marly alluvial soil, some remains of an extinct ruminant, consisting of a skull, with the core of one horn attached, the former being of an extraordinary length in proportion to its breadth. It forms part of the collection of 1847, and must speak for itself†.

I have no doubt that a diligent search in the deep ruts or ravines that everywhere intersect the great plains of the interior would produce a vast number of extinct mammalian remains perfectly new to science.

* The specimens above referred to comprise both casts of some aloe-like plants and semicylindrical stem-like bodies. For observations on the calcareous casts of plant-remains near Simons Town and elsewhere, see also Darwin's 'Volcanic Islands,' p. 146; Clarke, Proc. Geol. Soc. vol. iii. p. 421; and C. Abel's Voyage, p. 308.—Ed.

† See also Proc. Geol. Soc. vol. iii. p. 152; and Trans. vol. vii. p. 59.—Ed.

Description of Fossils from the Secondary Rocks of Sunday River and Zwartkop River, South Africa, collected by Dr. Atherstone *and* A. G. Bain, Esq. *By* D. Sharpe, Esq., F.R.S., Pres. G.S. &c.

[Plates XXII. XXIII. XXVIII.]

Pinna Atherstoni, Sharpe. Pl. XXII. fig. 1.

P. testâ brevi, triangulari, subarcuatâ, longitudinaliter costatâ et medio angulatâ, anticè subquadratâ: costis numerosis inæqualibus, undulatis; lineis concentricis irregularibus decussatis.

Shell triangular, short, slightly curved, with a longitudinal keel below the middle of each valve, which is more prominent anteriorly, giving the anterior end of the shell a rhomboidal section: valves covered with numerous unequal, slightly waving, longitudinal ribs; crossed by undulating, irregular lines of growth.

Length $4\frac{1}{2}$ inches; breadth $2\frac{1}{2}$ inches; thickness $1\frac{1}{4}$ inch.

From Sunday River; found at C. Roe's drift, in a grit with fragments of shells and wood.

This *Pinna* is nearly related to *P. Hartmanni* of Zieten, Goldf. t. 127. fig. 3, which occurs in the Lias of Würtemberg.

Fig. 1 *a*, side view; fig. 1 *b*, transverse section of the anterior part.

Modiola Bainii, Sharpe. Pl. XXII. figs. 2 & 3.

M. testâ transversim elongatâ, subrectâ, concentricè costatâ: costis medio divisis.

Shell transversely elongated, with the back straight and the ventral edge very slightly curved: ornamented with numerous concentric ribs, which are sloping and very strong near the back, but divide into two or three branches before reaching the middle of the valves; these reunite on the lateral transverse keel and then continue small and parallel to the ventral margin. The umbo not having been seen, the proportions of the shell cannot be accurately ascertained; the length was probably more than eight times the breadth.

From Sunday River; found at C. Roe's drift, in a grit with fragmentary shells and wood.

This elegant shell has some resemblance to *M. plicata*, Sow., of the Middle Oolites; but it is straighter, much more elongated, and more regularly ornamented.

Fig. 2, fragment of a large specimen; fig. 3 *a*, fragment of younger shell; fig. 3 *b*, section of fig. 3 *a*.

Perna Atherstoni, Sharpe. Pl. XXII. fig. 4.

P. testâ triangulari, subglabrâ: cardinis ligamenti foveis numerosis, confertis.

Shell nearly triangular, smooth, anterior side sloping, posterior side rounded:

valves of moderate thickness. Hinge-area of moderate depth; ligamental hollows broader than the spaces between them.

Length 2 inches; breadth $1\frac{1}{4}$ inch; thickness $\frac{1}{2}$ inch.

Found at Geelhoutboom, in greenish grit with fragmentary shells.

An inconspicuous shell, with no marked characters, which it would be difficult to distinguish from several European species.

Fig. 4, left valve; fig. 4 *a*, interior of right valve of another specimen; fig. 4 *b*, anterior side of fig. 4.

Trigonia Vau, Sharpe. Pl. XXII. fig. 5.

T. testâ ovato-trigonâ, inflatâ, tuberculato-costatâ: latere antico brevi, rotundato; latere posteriori producto: costis obliquis subtuberculatis, anterioribus retrorsum, posterioribus antrorsum inclinatis, medio angulatis: areâ magnâ, declivi, bi-excavatâ, transversim lineatâ.

Shell ovato-triangular, short and rounded anteriorly, produced posteriorly: umbones projecting, very near the anterior extremity: area broad, divided in two parts by a slight longitudinal ridge, and crossed by faint lines of growth: sides ornamented with slightly tuberculated ribs, which form an angle of 70° to 90° on the middle of the side of the valve; the anterior ribs, small and numerous, slope diagonally backwards; the posterior ribs, strong and about ten in number, slope diagonally forwards; the meeting of these ribs resembles the form of the letter V, as in the genus *Goniomya*.

Length 2 inches; depth $1\frac{1}{4}$ inch.

Found at Sunday River, in greenish-grey grit, with fragments of wood and shells; and in a shelly grit at the Zwartkop River.

Pholadomya Dominicalis, Sharpe. Pl. XXII. fig. 6.

P. testâ tenuissimâ, transversim ovatâ, costatâ: latere antico brevi, sublævi; posteriori elongato, subrecurvo: umbonibus anticis, incurvis: areâ cardinali angustâ, inconspicuâ: costis 10 retrorsum vergentibus, primâ remotiusculâ, reliquis subæquidistantibus: rugis concentricis inconspicuis.

Shell very thin, transversely ovate; anterior end very short and nearly closed; posterior end produced, with the lower margin rounded off and the upper side slightly recurved, and moderately gaping: umbos forward and incurved: cardinal area narrow and ill-defined: ribs ten, radiating from the umbo and sloping backward; the first widely separated from the rest, which are nearer together and nearly at equal distances from one another.

Length $1\frac{1}{4}$ inch; breadth $2\frac{1}{4}$ inches; thickness 1 inch.

Found at Sunday River, in greenish grit.

This shell is nearly related to *P. Hausmanni*, Goldf., of the Lias of Hanover, from which it may be distinguished by having only one rib (instead of two) more

distant than the rest; by the rounding-off of its lower posterior margin; and its less marked cardinal area: it differs from *P. similis*, Ag., of the Middle Oolite of the Jura, in wanting ribs on the anterior portion of the shell: it is also near to *P. decemcostata*, Römer, of the Upper Oolite of Germany. Should the above-mentioned forms be hereafter united as one species, the African shell must be placed with them.

Myacites? Bainii, Sharpe. Pl. XXII. fig. 7.

M. testâ tenui, transversim ovato-elongatâ; anticè posticèque hiante: umbonibus subanticis, prominulis: margine ventrali recto.

Shell thin, transversely elongated; gaping and rounded at both ends; somewhat compressed in the middle, and with a straight ventral margin: lines of growth irregular.

Length $1\frac{1}{4}$ inch; breadth $2\frac{1}{2}$ inches; thickness $\frac{7}{8}$ths of an inch.

Found at Sunday River, in greenish shelly grit.

An inconspicuous shell, of which the true characters can only be ascertained after the interior of the valves shall have been seen.

Ceromya papyracea, Sharpe. Pl. XXII. fig. 8.

C. testâ tenuissimâ, ovato-rhomboideâ, ventricosâ; anticè abbreviatâ, inflatâ; posticè compressâ, subproductâ; margine cardinali recto: umbonibus anticis, prominentibus, incurvis: lineis concentricis crebris.

Shell very thin, nearly rhomboidal, ventricose; anterior end short and inflated, with large incurved umbos; posterior end somewhat produced and gradually flattened: cardinal margin straight; ventral margin slightly rounded: valves slightly unequal, covered with fine, close-set, regular, concentric lines of growth, which on the middle of the right valve are crossed by a few very faint, radiating lines, which are slightly marked on the internal cast.

Length $1\frac{1}{4}$ inch; breadth $1\frac{1}{2}$ inch; thickness 1 inch.

Found at Zwartkop River.

I place this species in the genus *Ceromya* with some doubt; the extreme thinness of the shell excludes it from *Isocardia*; the slight inequality of the valves, the faint rays on the right valve, and the slightly waved outline of the posterior margin, indicating that it is probably a gaping shell, bring it nearer to *Ceromya* than to *Cardiomorpha*.

Cyprina rugulosa, Sharpe. Pl. XXII. fig. 9.

C. testâ rhomboideo-ovatâ, anticè læviusculâ, declivi, posticè inflatâ; concentricè rugosâ: umbonibus anticis prominulis: dente cardinali laterali obsoleto.

Shell thick, transversely ovato-rhomboidal; inflated in the middle and posterior

portions, thinner anteriorly: valves traversed by numerous concentric lines, which are nearly obsolete in the middle of the shell, but rugose on the posterior side. On the left valve the anterior lateral tooth is nearly obsolete.

Length $1\frac{1}{4}$ inch; breadth $1\frac{1}{2}$ inch; thickness $\frac{3}{4}$ of an inch.

Found at Sunday River, in greenish shelly grit.

Fig. 9 *a*, exterior of the left valve; fig. 9 *b*, hinge of the left valve: the posterior tooth has been partially broken away.

Arca Atherstoni, Sharpe. Pl. XXII. fig. 10.

A. testâ trapezoidali; anticè brevi; medio depressâ; posticè elongatâ, obliquè truncatâ, plicatâ: costis minutis numerosis radiantibus, lineis concentricis decussatis.

Shell trapezoidal; short anteriorly; with a broad depression down the middle, bounded by a broad, rounded, transverse keel; obliquely sloping posteriorly: the anterior and middle portions of the valves are ornamented with numerous fine radiating lines, crossed by irregular lines of growth: the sloping posterior portion is divided into three obliquely-longitudinal furrows.

Length $\frac{3}{8}$ths of an inch; breadth $\frac{7}{8}$ths.

Found at Sunday River, in a shelly sand-rock.

[Neither the radiating lines nor the posterior furrows are sufficiently shown in the figure.]

Psammobia Atherstoni, Sharpe. Pl. XXII. fig. 11.

P. testâ compressâ, ovali; anticè rotundatâ; posticè subcompressâ: rugis concentricis inæqualibus.

Shell oval, flattish, regularly rounded anteriorly, slightly sloping on the posterior dorsal side: valves crossed irregularly by unequal concentric ridges.

Length $\frac{3}{4}$ of an inch; breadth $1\frac{1}{4}$ inch; thickness $\frac{3}{8}$ths of an inch.

Found at Sunday River and near Enon, in a grit sometimes full of the casts of the shell.

Fig. 11 *a*, cast from the impression of the left valve; figs. 11 *b* & 11 *c*, two views of a cast of the interior.

The casts show the hinge to have had two strong teeth on the left valve and one on the right valve, with a sharp edge extending laterally along the dorsal margin of the valves on each side of the cardinal teeth.

Ammonites Atherstoni, Sharpe. Pl. XXIII. fig. 1.

A. testâ subglobosâ, costatâ: anfractibus paucis, rotundato-inflatis, lateribus 15–25-costatis, dorso rotundatis multicostatis: costis rectis, acutis, ad latera 3–4-furcatis, deinde super dorsum continuis: umbilico parvo, profundo: aperturâ semi-ovali.

Shell subglobose, with few inflated whorls, ornamented with numerous straight

sharp ribs: 15 to 25 large ribs near the umbilicus, rising into spines, and then each dividing into 3 or 4 smaller ribs, which cross over the rounded back: umbilicus narrow, deep, and well-defined: aperture semi-oval.

The young shell only differs from the adult in having rather fewer ribs.

Diameter of the figured specimen 5 inches; width of opening $3\frac{1}{2}$ inches; height of the last whorl $2\frac{1}{2}$ inches. Some broken specimens in the collection indicate a much larger size.

Found at Sunday River; some specimens occur in a crushed condition. A fragment of a large individual, of apparently the same species, is from the Zwartkop River.

This Ammonite is related to *A. macrocephalus*, of the Middle Oolite of Europe, and to *A. Herveyi*, of the Lower Oolite. Our specimens do not show the septa.

Ammonites Bainii, Sharpe. Pl. XXIII. fig. 2.

A. testâ subglobosâ, costatâ: anfractibus paucis, rotundato-inflatis, lateribus 15-costatis, dorso rotundatis, 40-costatis: costis acutis, antrorsum subincurvis, ad latera 2–3 furcatis, deinde super dorsum continuis: umbilico parvo, profundo: aperturâ semicirculari, interdum contractâ.

Shell subglobose, with few inflated whorls; ornamented with numerous, slightly bent, sharp ribs, about 15 in number near the umbilicus; the ribs divide on each side of the whorl into 2 or 3, which continue across the round back: umbilicus narrow, deep, and well-defined: aperture semicircular, from time to time contracted; and the contractions marked by a stouter rib, projecting forward more than the rest.

Diameter 2 inches; width of opening $1\frac{1}{4}$ inch; height of the last whorl $\frac{3}{4}$ of an inch.

Found at Sunday River.

With some general resemblance to *A. Atherstoni*, this species is not only distinguished by having fewer ribs, but also by the periodical contractions of the mouth, which connect it with *A. Humphriesianus*, *A. Brackenridgii*, and *A. linguiferus* of the Lower Oolite of Europe.

Gryphæa imbricata, Krauss, sp. Pl. XXIII. fig. 3.

Exogyra imbricata, Krauss, Acad. Nat. Cur. xxii. pl. 50. fig. 2.

G. testâ ovato-oblongâ, crassissimâ, squamoso-rugosâ: valvâ inferiori naviculari, apice sinistrorsum incurvo, sulco laterali obsoleto; superiori concaviusculâ, apice recurvo.

Shell ovate-oblong, very thick, externally scaly, attached when young: lower

valve boat-shaped, with an obscure lateral lobe and the apex incurved towards the left; a small scar on the left side of the apex, marking its original attachment; upper valve squamose, slightly concave, with the apex bent back towards the left, so that the beginning of the ligamental pit is exposed.

Length 3 inches; breadth $2\frac{1}{4}$ inches; depth of lower valve $1\frac{1}{2}$ inch.

Found at Sunday River and Zwartkop River.

Dr. Krauss places this shell in the genus *Exogyra*, comparing it to *E. Couloni*: it is, however, a *Gryphæa*, as the upper valve has not the spiral turn nor the lateral hinge-tooth which distinguish the former genus: the species nearest to it in form is the *G. incurva* of the Lias, from which it is readily distinguished by the recurved apex of the upper valve.

Fig. 3 *a*, side view of shell, with both valves; fig. 3 *b*, exterior of the upper valve of another specimen.

Gastrochæna Dominicalis, Sharpe. Pl. XXIII. fig. 4.

G. testâ ovato-oblongâ, anticè inflatâ abbreviatâ, posticè angustatâ: valvis concentricè costulatis; costis nodulosis: tubo brevi, subinfundibuliformi.

Shell oblong, round and shortened anteriorly, tapering posteriorly: valves covered with numerous fine concentric ribs, which are ornamented with a row of small closely-set tubercles: tube short, enlarging rapidly from a small opening, and blunt at the lower end.

Length of the tube $\frac{1}{3}$rd of an inch; greatest diameter $\frac{1}{5}$th.

Found at Sunday River, near Enon. Other specimens of *Gastrochænæ* are found in wood, and others (one of them 1 inch long) in an old massive shell of a *Trigonia*; all from Sunday River.

Fig. 4 *a*, a fragment of ~~bone~~ wood bored all round by *Gastrochænæ*, of the natural size; fig. 4 *b*, dorsal view of a pair of valves, twice their natural size.

Neritopsis ? turbinata, Sharpe. Pl. XXIII. fig. 5.

N. testâ depresso-globosâ, crassâ; longitudinaliter lineis insculptis, transversim sulcis obsoletis ornatâ.

Shell thick, globose, with four rounded whorls, separated by a deep furrow, and ornamented with fifteen equidistant deeply impressed lines, which are crossed by numerous, unequal, slightly impressed lines of growth.

Height $\frac{5}{8}$ths of an inch; breadth $\frac{3}{4}$.

Found at Sunday River.

The aperture not having been seen, the genus is left in doubt.

Avicula Bainii, Sharpe. Pl. XXVIII. fig. 10.

A. testâ subrhomboidali, obliquâ, lævigatâ, medio gibbosâ; anticè abbreviatâ, tumidiusculâ; posticè alatâ, depressâ.

Shell somewhat rhomboidal, oblique, nearly smooth; gibbous in the middle; anterior portion short and tumid; posterior expanded into a broad flat wing.

Length $\frac{1}{6}$th of an inch; breadth the same.

Found in the lowest strata of the Zwartkop crag.

Only one imperfect specimen of the left valve has been seen.

Modiola Atherstoni, Sharpe. Pl. XXVIII. fig. 11.

M. testâ transversim oblongâ, gibbosâ, concentricè striatâ, anticè obtusâ, posticè rotundatâ expansâ.

Shell transversely oblong, gibbous, concentrically striated, short and obtuse in front, widened and rounded posteriorly.

Length $\frac{1}{10}$th of an inch; breadth $\frac{1}{5}$th of an inch.

Abundant in the lowest strata of the Zwartkop crag.

Sanguinolaria? Africana, Sharpe. Pl. XXVIII. fig. 12.

S.? testâ transversim oblongâ, depressâ, anticè abbreviatâ rotundatâ, posticè expansâ, concentricè rugosâ striatâque.

Shell thin, transversely oblong, depressed; umbos near the anterior end, which is short and rounded; posterior end broad and somewhat flattened, with a shallow furrow near the dorsal margin: ornamented with eight or ten broad concentric folds, which are visible in the cast, between which are fine concentric striæ.

Length $\frac{2}{10}$ths of an inch; breadth $\frac{1}{10}$th of an inch.

Found in the lowest strata of the Zwartkop crag.

Cyrena? Bainii, Sharpe. Pl. XXVIII. fig. 13.

C.? testâ transversim ovatâ, gibbosâ, concentricè striatâ; umbonibus prominentibus submedianis.

Shell transversely ovate, gibbous, slightly inequilateral, concentrically wrinkled; umbos large, a little in advance of the middle.

Length $\frac{3}{8}$ths of an inch; breadth $\frac{1}{2}$ an inch.

Found in the lowest strata of the Zwartkop crag.

Trochus Bainii, Sharpe. Pl. XXVIII. fig. 14.

T. testâ minutâ, pyramidali, imperforatâ; anfractibus angulatis, longitudinaliter undato-striatis; infra transversim rugosâ: aperturâ subquadratâ: angulo spirali 50°.

Shell minute, pyramidal, imperforate, with four angular whorls which are

indistinctly keeled at their lower edge, and crossed by numerous longitudinal undulations. Angle of the spire 50°.

Length $\frac{1}{10}$th of an inch.

Found in the lowest strata of the Zwartkop crag.

Turbo Atherstoni, Sharpe. Pl. XXVIII. figs. 15 & 16.

T. testâ minutâ, turbinatâ: anfractibus 4, angulatis; supernè planis, longitudinaliter striatis; medio bicarinatis: angulo spirali 75°.

Shell minute, turbinated: whorls four, angular; nearly flat and longitudinally striated above; with a broad flat band round the middle, bounded by two strong keels: angle of the spire 75°.

Length $\frac{1}{10}$th of an inch.

Found in the lowest strata of the Zwartkop crag.

Turbo Bainii, Sharpe. Pl. XXVIII. figs. 17 & 18.

T. testâ minutâ, turbinatâ: anfractibus 4, angulatis, longitudinaliter striatis; supernè planis; medio tricarinatis; infra tricarinatis: angulo spirali 65°.

Shell minute, turbinated: whorls four, angular, and longitudinally striated; nearly flat above; with three strong keels on the exposed middle part and three keels on the lower part: angle of the spire 65°.

Length $\frac{1}{8}$th of an inch.

Common in the lowest strata of the Zwartkop crag.

Since the above description was written, some specimens belonging to this species have been found in breaking up some greenish grit with *Ostræa* from Sunday River. These specimens are larger than the above-described; the largest is $\frac{1}{2}$ inch in length.

Acteon Atherstoni, Sharpe. Pl. XXVIII. fig. 19.

A. testâ fusiformi: anfractibus 6, rotundatis; supernè planis; infra transversim impresso-lineatis: angulo spirali 40°.

Shell fusiform, with six rounded whorls, which are smooth on the upper part and ornamented on the lower part with about fifteen impressed transverse lines: angle of the spire 40°.

Length $\frac{1}{6}$th of an inch.

Found in the lowest strata of the Zwartkop crag.

Natica Atherstoni, Sharpe. Pl. XXVIII. fig. 22.

N. testâ oblongâ: anfractibus convexis, medio subangulatis longitudinaliter striatis: angulo spirali 75°.

Shell oblong, finely striated by the lines of growth: whorls four, convex, a little

depressed above, which gives them a slight approach to angularity at the middle: angle of the spire 75°.

Length ½ an inch.

Found in the lowest strata of the Zwartkop crag.

List of the Fossils from the Sunday and the Zwartkop Rivers.

[The Sunday River fossils included in the collections presented to the Geological Society are enveloped in a greenish-grey calcareous earthy rock, sometimes a limestone, and often passing into a sand-rock or a grit; green grains are nearly always present, and sometimes in great abundance.

The fossils from the Zwartkop River district are (excepting the *Astarte*, *Gryphæa*, and *Ostræa*) chiefly casts, often ferruginous, thickly set in a yellowish calcareous rock. For a detailed description of a section of the fossiliferous rocks of the Zwartkop River, see Dr. Krauss's Memoir in the *Nova Acta Acad. Cæs. Leop. Carol. Nat. Cur.* vol. xxii. pars 2, 1850, p. 439; and *Quart. Journ. Geol. Soc.* vol. vi. part 2. Miscell. p. 120.]

Ammonites Atherstoni, *Sharpe*. Pl. XXIII. fig. 1	Sunday and Zwartkop Rivers.
Ammonites Bainii, *Sharpe*. Pl. XXIII. fig. 2	Sunday River.
Nautilus, undeterm. (5½ inches in diameter)	Sunday River.
Neritopsis? turbinata, *Sharpe*. Pl. XXIII. fig. 5	Sunday River.
Small Gasteropods. One like fig. 23, Pl. XXVIII., and ¼ inch long; one like fig. 25, Pl. XXVIII., and ⅝ inch long; and one like fig. 18, Pl. XXVIII., and ½ inch long; these are in a greenish grit from Sunday River, and are evidently finer individuals of the species from "the lowest strata of the Zwartkop crag" (see p. 203).	Sunday River.
Ostræa, spp. Single individuals; attached to shells and wood; and in mass	Sunday River.
Gryphæa imbricata, *Krauss*, sp. (*loc. cit.* pl. 50. fig. 2.) Pl. XXIII. fig. 3	Sunday and Zwartkop Rivers.
Perna Atherstoni, *Sharpe*. Pl. XXII. fig. 4	Sunday River.
Gervillia dentata, *Krauss* (*loc. cit.* pl. 50. fig. 1)	Sunday and Zwartkop Rivers.
Pinna Atherstoni, *Sharpe*. Pl. XXII. fig. 1	Sunday River.
Lima, sp. (undeterm.)	Sunday River.
Modiola Bainii, *Sharpe*. Pl. XXII. figs. 2 & 3	Sunday River.
Arca Atherstoni, *Sharpe*. Pl. XXII. fig. 10	Sunday River.
Cucullæa? cancellata, *Krauss* (*loc. cit.* pl. 48. fig. 2).	Zwartkop River.
Trigonia Vau, *Sharpe*. Pl. XXII. fig. 5	Sunday River.

Trigonia Herzogii, *Hausmann*, sp. (*Krauss, loc. cit.* pl. 48. fig. 3; *Goldfuss, Pet. Germ.* pl. 137. fig. 5)	Sunday and Zwartkop Rivers.
———, sp. (?).	Sunday River.
This variety (or possibly distinct species) is closely allied to *Trigonia Herzogii*, but is more quadrate in outline than the common variety, the anterior edge being truncate; and the costal rows of knobs turn forwards as they approach the ventral border, instead of passing downwards and backwards. These specimens came from Algoa Bay, and apparently have been derived from the Sunday River district, from the aspect of their matrix. They were lately presented to the Society's Museum by J. S. Bowerbank, Esq., F.G.S.	
——— conocardiformis, *Krauss*, sp. (*loc. cit.* pl. 49. fig. 1) .	Sunday and Zwartkop Rivers.
——— ventricosa, *Krauss*, sp. (*loc. cit.* pl. 49. fig. 2)	Zwartkop River.
Anoplomya lutraria, *Krauss* (*loc. cit.* pl. 49. fig. 1)	Zwartkop River.
Pholadomya Dominicalis, *Sharpe*. Pl. XXII. fig. 6	Sunday River.
Myacites Bainii, *Sharpe*. Pl. XXII. fig. 7	Sunday River.
Ceromya papyracea, *Sharpe*. Pl. XXII. fig. 8	Zwartkop River.
Gastrochæna Dominicalis, *Sharpe*. Pl. XXIII. fig. 4	Sunday River.
Psammobia Atherstoni, *Sharpe*. Pl. XXII. fig. 11.	Sunday River.
Cyprina rugulosa, *Sharpe*. Pl. XXII. fig. 9	Sunday River.
Astarte Herzogii, *Hausmann*, sp. (*Krauss, loc. cit.* pl. 47. fig. 2; *Goldf. Pet. Germ.* pl. 149. fig. 10)	Zwartkop River.
———, Bronnii, *Krauss* (*loc. cit.* pl. 48. fig. 1)	Zwartkop River.
Several small Bivalves (undeterm.); from Sunday River and from	Zwartkop River.
Serpula, sp. Large single tube, on *Trigonia Herzogii*	Sunday River.
———, sp. Small numerous winding tubes, on *Gryphæa* . .	Sunday River.
Fucoid? Branching, with clavate branches, 1 inch long; in greenish-grey sandstone containing a small specimen of *Trigonia conocardiformis*?	Sunday River.
Wood; lignite (almost jet), with *Ostreæ* attached	Sunday River.
——— (coniferous); calcareous, from Geelhoutboom . . .	
——— (coniferous); calcareous, perforated by *Gastrochænæ*. Pl. XXIII. fig. 4	
———; calcareous	Lowest strata of Zwartkop crag.

Sec pal. 198.228

Note.—None of these Mollusks above enumerated can be identified with any known European species; but the forms which they most nearly resemble are those which are found in the middle and lower part of the Oolitic series. Mr. Bain probably places the beds rather too low when he compares them to the Lias; but Dr. Krauss's proposal to place them in the Cretaceous series seems to rest on still weaker grounds.—Daniel Sharpe.

Note.—The following shells are of minute size, and occur together in a hard argillaceous limestone of a reddish colour, labelled "Snieuwberg?" by Mr. Bain, but lately recognized (since the figures were drawn) as identical with a fragment, marked "Lowest strata of the Zwartkop crag," in Dr. Atherston's collection. The latter label has been adopted. This shelly rock contains also fragments of wood and bone, and is probably of estuarine origin, as, with some fluviatile or lacustrine shells, it contains a number of very minute marine mollusks, of genera often found in brackish water: these may be dwarfish individuals of species which would have reached a larger size in purely marine waters*. Believing this to be the case, I have not ventured to compare them with any published species; nor do I think that any conclusions as to the age of the bed in which they occur can safely be drawn from the shells themselves.—Daniel Sharpe.

Avicula Bainii, *Sharpe*. Pl. XXVIII. fig. 10.	Lowest strata of the Zwartkop crag.
Modiola Atherstoni, *Sharpe*. Pl. XXVIII. fig. 11	
Sanguinolaria? Africana, *Sharpe*. Pl. XXVIII. fig. 12 . .	
Cyrena? Bainii, *Sharpe*. Pl. XXVIII. fig. 13	
Trochus Bainii, *Sharpe*. Pl. XXVIII. fig. 14	
Turbo Atherstoni, *Sharpe*. Pl. XXVIII. figs. 15 & 16 . .	
—— Bainii, *Sharpe*. Pl. XXVIII. figs. 17 & 18 . . .	
Acteon Atherstoni, *Sharpe*. Pl. XXVIII. fig. 19	
Natica Atherstoni, *Sharpe*. Pl. XXVIII. fig. 22	

Description of Palæozoic Fossils from South Africa.

By Daniel Sharpe, Esq., F.R.S., Pres. G.S., and J. W. Salter, Esq., F.G.S.

Introduction.

The few South African fossils originally collected by Dr. Andrew Smith, in the Cedarberg, and referred to in the "Silurian System," are identical with those found by Mr. Bain more to the southward, in the Bokkeveld, and have been illustrated together with the latter in the following pages.

As we are unable to identify any of these South African fossils with species which have been described from districts where the age of the formations has been

* Since the above was written, some of the species of shells occurring in this rock have been found to be represented by large individuals in the greenish-grey shelly grit of the Sunday River: see p. 201.—Editor.

fully ascertained, we can only conjecture their place in the geological series from their analogy with European forms. This comparison, however, while it tends to invalidate the conclusion that any of them are from true Silurian strata, as formerly supposed, makes it very probable that they belong to the Devonian.

This conclusion was indeed arrived at when the specimens were first examined; and a letter to that effect from one of the authors was read at the end of Mr. Bain's paper, which it is not thought necessary to print here. At the same time, and quite independently, the same result was arrived at by Dr. F. Sandberger, and published in the 'Neues Jahrbuch für Min. u. s. w.' for 1852, p. 581, &c.*

We entirely agree with Dr. Sandberger in rejecting as improbable the association of Lower and Upper Silurian species of Trilobites and Shells in the same beds with Devonian types; nor do we think it necessary to suppose that any beds of older date occur in the localities mentioned, which might have afforded such Silurian species; and in the following descriptions we shall point out some fossils which we believe to have been erroneously identified as Silurian by preceding observers.

We cannot, however, follow Dr. Sandberger in referring certain Brachiopods, &c. to European species of Devonian fossils: the only locality where any of these South African species have previously been found is in the Falkland Islands; and it is very remarkable that, of the nine species brought from those islands by Mr. Darwin, and figured in the 2nd volume of our Quarterly Journal, pl. 10 & 11, five are contained in Mr. Bain's collection from the Cape.

This interesting fact teaches us that the Devonian formation had a very wide range in the Southern Hemisphere; but, as far as we yet know, it was peopled by species different from, though nearly allied to, those which lived at the same period in the Northern regions.

This would be in harmony with all that is known of the distribution of fossils in Palæozoic times. Both in the Silurian, Devonian, and Carboniferous epochs we have proof of a geographical limitation of groups of species, perhaps less traceable in the Carboniferous,—but most distinctly so in the Silurian. The fossils above described furnish an additional proof of this limitation during the Devonian period.

General List of the Palæozoic Fossils from South Africa.

Spirifer Antarcticus, *Morris & Sharpe*. Pl. XXVI. figs. 1, 2, & 5 .	Warm Bokkeveld: Falkland Islands.
—— Orbignii, *Morris & Sharpe*. Pl. XXVI. figs. 3, 4, & 6 .	Warm Bokkeveld: Falkland Islands.

* See also Quart. Journ. Geol. Soc. vol. ix. part 2. Miscell. p. 1.

Orthis palmata, *Morris & Sharpe.* Pl. XXVI. figs. 7–10 . .	Cold Bokkeveld, Warm Bokkeveld, Cedarberg, Hottentots Kloof, and Kokmans Kloof: Falkland Islands.
Terebratula Bainii, *Sharpe.* Pl. XXVI. figs. 11 & 12 . . .	Warm Bokkeveld.
Strophomena Bainii, *Sharpe.* Pl. XXVI. figs. 13 & 17 . . .	Warm Bokkeveld.
——— Sullivani, *Sharpe.* Pl. XXVI. figs. 18 & 19	Warm Bokkeveld: Falkland Islands.
Chonetes, sp. Pl. XXVI. fig. 14	Warm Bokkeveld.
———, sp. Pl. XXVI. figs. 15 & 16	Warm Bokkeveld.
Atrypa, sp.	Hottentots Kloof.
Orbicula Bainii, *Sharpe.* Pl. XXVI. figs. 20–23	Cedarberg, Gydow Pass, and Hottentots Kloof.
Solenella antiqua, *Sharpe.* Pl. XXVII. fig. 1	Leo Hoek.
——— rudis, *Sharpe.* Pl. XXVII. fig. 6	Hottentots Kloof.
Cleidophorus Africanus, *Sharpe.* Pl. XXVII. figs. 2 & 4 . .	Cedarberg and Gydow Pass.
——— abbreviatus, *Sharpe.* Pl. XXVII. fig. 3	Gydow Pass, Bokkeveld.
Leda inornata, *Sharpe.* Pl. XXVII. fig. 5	Hottentots Kloof.
Nucula (cast)	Gydow Pass.
Leptodomus? ovatus, *Sharpe.* Pl. XXVII. fig. 7	Leo Hoek.
Sanguinolites? corrugatus, *Sharpe.* Pl. XXVII. fig. 8 . . .	Leo Hoek.
Modiolopsis? Bainii, *Sharpe.* Pl. XXVII. fig. 9	Leo Hoek.
Anodontopsis? rudis, *Sharpe.* Pl. XXVII. fig. 10	Leo Hoek.
Bivalves, some undetermined.	Leo Hoek, Hottentots Kloof, and Gydow Pass.
Littorina? Bainii, *Sharpe.* Pl. XXVII. figs. 11 & 12 . . .	Gydow Pass.
Conularia Africana, *Sharpe.* Pl. XXVII. fig. 13	Cedarberg.
———, sp.	Cedarberg.
Bellerophon quadrilobatus, *Salter.* Woodcut, p. 214, figs. 1 & 2	Warm Bokkeveld.
Theca subæqualis, *Salter.* Woodcut, p. 214, figs. 3 & 4 . .	Warm Bokkeveld.
Homalonotus Herschelii, *Murchison.* Pl. XXIV.	Warm Bokkeveld, Gydow Pass, and Leo Hoek.
Phacops Africanus, *Salter.* Pl. XXV. figs. 1–9	Cedarberg, Gydow Pass, and Hottentots Kloof.
——— Caffer, *Salter.* Pl. XXV. figs. 10–13	Gydow Pass and Leo Hoek.
———, 2 spp.	Gydow Pass and Leo Hoek.
Typhloniscus Bainii, *Salter.* Pl. XXV. fig. 14	Gydow Pass.
Tentaculites crotalinus, *Salter.* Pl. XXV. figs. 15–18 . . .	Hottentots Kloof and Warm Bokkeveld.
Serpulites Sica, *Salter.* Pl. XXV. fig 19	Warm Bokkeveld.

Encrinital joints and stems.	Pl. XXV. figs. 21–28	Warm Bokkeveld, Cold Bokkeveld, Cedarberg, Gydow Pass, and Kokmans Kloof.
Ophiocrinus Stangeri, *Salter*.	Pl. XXV. fig. 20	?

Description of Palæozoic Mollusca from South Africa.

By Daniel Sharpe, Esq., F.R.S., Pres.G.S.

Spirifer Antarcticus, Morris and Sharpe, Quart. Journ. Geol. Soc. vol. ii. pl. xi. fig. 2. Pl. XXVI. figs. 1, 2, & 5.

S. testâ crassâ semicirculari, costis 20–24 rotundatis elevatis concentricè subimbricatis: costâ mediâ ventrali magnâ, elevatâ, imbricatâ: sulco medio dorsali lato, profundo, rotundato: areâ cardinali latitudine valvarum; dorsali elevatâ, triangulari, longitudinaliter lineatâ; ventrali elevatâ, rectâ.

Shell transversely semicircular, with twenty to twenty-four prominent, rounded ribs, slightly imbricated by the concentric lines of growth: mesial ridges of the ventral valve large, elevated, and imbricated; mesial furrow of the dorsal valve large, deep, and rounded. Hinge-area of the breadth of the shell; on the dorsal valve high and triangular, with strongly marked longitudinal lines; on the ventral valve high and bounded by parallel lines.

Breadth $2\frac{1}{2}$ inches; length of dorsal valve $1\frac{1}{2}$ inch, of ventral valve $1\frac{1}{4}$ inch; height of hinge-area on the dorsal valve $\frac{1}{2}$ inch, on the ventral valve $\frac{1}{4}$ inch.

Found in the Warm Bokkeveld; occurring abundantly as casts in a hard grey siliceous rock, together with casts of *Sp. Orbignii*, *Terebratula Bainii*, *Orthis palmata*, and *Chonetes*, chiefly on the bedding-planes of the rock; also in a light-coloured soft sandstone of the same locality.

It has been also found in the Falkland Islands by Mr. C. Darwin.

The better preservation of the African specimens enables me to improve the description originally given of this species; but it is still far from complete: its most marked feature is the height of the hinge-area on both valves.

Fig. 1, cast of the interior of the dorsal valve; fig. 2, cast of the interior of the ventral valve, with the exterior of the dorsal area; fig. 3, exterior of the dorsal valve, from a gutta-percha mould of an impression of the shell.

Von Buch has described a species of *Spirifer* brought by Dr. Krauss from Kok-

man's Kloof* in the Cape of Good Hope, which has considerable affinity to this shell; it is *S. Capensis*, Von Buch, 'Bären-Insel,' p. 12. fig. 1. It differs from *S. Antarcticus* in having the mesial fold and sinus broader than in our species, and in having the beak of the dorsal valve bent over, and the area deeply curved; it also wants the imbricating lines of growth.

Spirifer Orbignii, Morris & Sharpe, Quart. Journ. Geol. Soc. vol. ii. pl. xi. fig. 3. Pl. XXVI. figs. 3, 4, & 6.

S. testâ semi-ovali, subæquivalvi: costis 16 rotundatis, elevatis, concentricè imbricatis: costâ mediâ ventrali latâ, elevatâ, imbricatâ, medio sulcatâ; sulco medio dorsali lato, profundo, rotundato, medio costato: areâ cardinali angustâ, latitudine valvarum.

Shell transversely semi-oval, nearly equivalved; with about sixteen prominent, rounded ribs, imbricated by strong concentric lines of growth: mesial ridge of the ventral valve large, prominent, and imbricated†, and marked by a slight medial furrow; mesial furrow of the dorsal valve broad, deep, and rounded, with a very slight medial rib: hinge-area of the breadth of the shell, narrow.

Breadth $2\frac{1}{2}$ to 3 inches; length 1 to $1\frac{1}{4}$ inch.

Found abundantly in the hard grey siliceous rock of the Warm Bokkeveld, with the preceding species; and also found in the Falkland Islands by Mr. C. Darwin.

I presume that this is the species which Dr. F. Sandberger has referred to *Spirifer macropterus*, Goldf., var. *mucronatus*, but I cannot concur in that view. All the African specimens have the uniformly curved outline represented in the figures, while *S. macropterus* has the outline of each wing in a curve more or less sigmoidal: the interiors of the valves are also different; *S. Orbignii* has a greater thickening of the interior of the dorsal valve towards the hinge, having the casts of the muscular impressions more prominent. The slight rib in the middle of the mesial furrow and the furrow in the mesial ridge of *S. Orbignii* (which should be more marked in the figures) are also distinguishing characters.

Fig. 3, cast of the interior of the dorsal valve; fig. 4, cast of the interior of the ventral valve; fig. 6, exterior of the ventral valve, from a gutta-percha mould of an impression of the shell.

Orthis palmata, Morris & Sharpe, sp. Pl. XXVI. figs. 7–10.

Atrypa palmata, Morris & Sharpe, Quart. Journ. Geol. Soc. vol. ii. pl. x. fig. 3.

O. testâ subhemisphæricâ, radiatim costatâ: valvâ ventrali depressâ, dorsali gibbosâ: costis 14–16 rotundatis, elevatis, simplicibus, sulcis rotundatis intermediis subæqualibus: lineâ cardinali subrectâ, breviusculâ.

* Kokman's Kloof is a pass in the mountains north of Swellendam.

† In the specimen fig. 6 the imbrication has been rubbed off the mesial ridge, and the furrow down it is also lost.

Shell nearly hemispherical, ribbed: ventral valve nearly flat, with the edges a little depressed; dorsal valve convex: both valves ornamented with fourteen to sixteen prominent, rounded, simple ribs, radiating from the umbo to the margin, and nearly equal in width to the rounded furrows between them. Hinge-line nearly straight, shorter than the breadth of the shell, which is rounded off at the extremities of the back.

Length $\frac{3}{4}$ of an inch; breadth 1 inch.

Found abundantly as casts in a ferruginous rock, together with casts of *Strophomena Bainii* and Encrinital joints, in the Cold Bokkeveld. *Orthis palmata* occurs also (with *Homalonotus* and *Tentaculites*) in the dark schists of the Warm Bokkeveld; with *Conularia* in the Cedarberg; in the light-colcured schists of Hottentots Kloof; and (with *Encrinites*) in a light-coloured schist from Kokman's Kloof, presented to the Geological Society's Museum by Major Colebrooke.

It has been also found in the Falkland Islands by Mr. C. Darwin.

Fig. 7, exterior of the ventral valve, from a gutta-percha mould of an impression of the shell; fig. 8, exterior of the dorsal valve, from a gutta-percha mould of an impression of the shell; fig. 9, interior of the ventral valve; fig. 10, interior of the dorsal valve.

Terebratula Bainii, Sharpe. Pl. XXVI. figs. 11 & 12.

T. testâ ovatâ, sublævi, concentricè rugatâ; valvâ dorsali convexâ, ventrali subdepressâ.

Shell ovate, nearly smooth, with a few deep concentric wrinkles; dorsal valve elevated; ventral valve slightly convex.

Length 1 inch; breadth $\frac{3}{4}$ of an inch; thickness about $\frac{3}{8}$ths of an inch.

Found plentifully as casts in a dark-grey siliceous rock, in the Warm Bokkeveld, together with casts of Spirifers and of *Orthis palmata*.

The specimens of this species in Mr. Bain's collection are all more or less crushed, and do not afford good materials for defining the species.

Fig. 11, exterior of the ventral valve, from a gutta-percha mould of an impression of the shell; fig. 12 *a*, cast of the interior of the ventral valve; fig. 12 *b*, cast of the interior of the dorsal valve.

Strophomena Bainii, Sharpe. Pl. XXVI. figs. 13 & 17.

S. testâ transversim semi-ovatâ, depressâ, subtiliter radiatâ: radiis numerosis simplicibus, alternatim minoribus; ad marginem 120–130: lineâ cardinali rectâ, valvarum latitudinem æquante.

Shell transversely semi-oval, depressed, covered on both valves with numerous, fine, simple rays, increasing in number as the shell enlarges by the insertion of smaller rays between the others, until they reach the number of 120 or 130 at the

margin: hinge-line of ventral valve straight, equal in length to the greatest width of the shell: ventral valve with a slight elevation near the umbo, below which is a mesial depression extending to the margin.

Length 1 inch; breadth $1\frac{3}{4}$ inch.

Found in the Warm Bokkeveld, in a nodule of ferruginous rock, together with casts of *Orthis palmata*; and in black schist and yellowish micaceous sand-rock of the same locality.

I take the specific characters from the ventral valve, fig. 13: if fig. 17 represent a dorsal valve, the hinge-area must be small. This shell much resembles *Strophomena Bechei*, M'Coy, sp., Carb. Foss. Ireland, pl. 22. fig. 3.

Fig. 13, exterior of ventral valve, from a gutta-percha mould of an impression of the shell; fig. 17, exterior of dorsal ? valve, from a similar mould.

Strophomena Sulivani, Morris & Sharpe, sp. Pl. XXVI. figs. 18 & 19.

Orthis Sulivani, Morris & Sharpe, Quart. Journ. Geol. Soc. vol. ii. pl. x. fig. 1.

S. testâ semi-ovatâ, striatâ; valvâ ventrali subplanâ, dorsali subgibbosâ: omninò striis numerosis radiantibus, bifurcantibus, ad marginem 150, lineisque paucis concentricis ornatâ: areâ cardinali altâ, triangulari, latitudinem valvarum æquante; foramine clauso.

Shell semi-ovate; ventral valve nearly flat, dorsal valve slightly gibbose: surface covered with fine sharp bifurcating rays, increasing at the margin to about 150 in number, and crossed by two or three ill-defined concentric lines: hinge-line nearly of the breadth of the shell: hinge-area high and triangular, with the large triangular foramen covered with a deltidium.

Width $1\frac{5}{8}$ inch; length $1\frac{1}{2}$ inch.

Found in dark-coloured schist and in reddish argillaceous rock in the Warm Bokkeveld; and also found in the Falkland Islands by Mr. C. Darwin.

Fig. 18, exterior of the ventral valve and hinge-area of the dorsal valve, from a gutta-percha mould of an impression of the shell; fig. 19, exterior of the dorsal valve, from a similar mould.

Chonetes, species undetermined. Pl. XVI. fig. 14.

Interior of the ventral valve, perhaps of the same species as the following.

From the Spirifer-rock of the Warm Bokkeveld.

Chonetes, species undetermined. Pl. XVI. figs. 15 & 16.

These figures probably represent the interior and exterior impressions of the dorsal valve of one species; but, having no positive proof of this, I have not ventured to name them. They are clearly distinct from *Chonetes sarcinulata*, Schloth., being much more finely striated than that species. Dr. F. Sandberger

quotes *C. sarcinulata* from the same formations at the Cape of Good Hope, but we have not found it among our specimens.

From the Spirifer-rock of the Warm Bokkeveld.

Some larger specimens of *Chonetes*? occur in a nodule of reddish rock from the Warm Bokkeveld.

Orbicula Bainii, Sharpe. Pl. XXVI. figs. 20–23.

Orbicula, sp., Quart. Journ. Geol. Soc. vol. ii. pl. x. fig. 5.

O. testâ ovato-circulari, depresso-conicâ, apice excentricâ, concentricè subrugatâ, radiatim subtilissimè striatâ.

Shell nearly circular, depressed-conical, with the apex slightly excentric, both valves covered with fine concentric wrinkles, which are crossed by very fine radiating striæ, scarcely visible to the naked eye.

Longest diameter $1\frac{1}{4}$ inch; shortest diameter $1\frac{1}{8}$ inch; height $\frac{3}{8}$ths of an inch.

Found in black schist at Gydow Pass (with *Littorina*); in soft light-coloured argillaceous rock (with *Strophomena Bainii*?) at Hottentots Kloof; and in nodules of dark-coloured rock at the Cedarberg (in one instance with *Chonetes*); and found in the Falkland Islands by Mr. C. Darwin.

Fig. 20 *a* & *b*, upper valve of a small specimen; fig. 20 *c*, part of the surface of 20*a*, magnified; fig. 21 *a* & *b*, upper valve of a larger specimen, which has lost nearly the whole of its shell; fig. 22, lower valve; fig. 23 *a*, fragment of the upper valve with the shell well preserved.

Solenella antiqua, Sharpe. Pl. XXVII. fig. 1.

S. testâ transversim ovatâ, concentricè rugoso-lineatâ; anticè rotundato-abbreviatâ; posticè subproductâ, rotundatâ, propè dorsum sinuatâ: cardine subarcuato; dentibus anterioribus 10 parvis, posterioribus numerosis minoribus.

Shell transversely ovate; anterior end broad, short, and rounded; posterior end somewhat produced, broad, with a small sinus near the dorsal margin: valves covered with fine concentric wrinkles: hinge-line slightly arched, with about ten small anterior, and more than twenty very small posterior teeth.

Length $1\frac{1}{2}$ inch; breadth $2\frac{1}{4}$ inches; thickness 1 inch.

Found at Leo Hoek, in a fine micaceous sandstone. There are five specimens in the collection, four of which have the valves united.

As the ligament of this and the following species was external, it is obviously incorrect to place them in the genus *Nucula*; the small posterior sinus shows their relation to *Solenella*, and proves them to have had a sinus in the pallial line.

Fig. 1 *a*, right valve; fig. 1 *b*, hinge of the same specimen.

Solenella rudis, Sharpe. Pl. XXVII. fig. 6.

S. testâ transversim rhomboideo-ovatâ; concentricè lineatâ et corrugatâ; anticè rotundato-abbreviatâ; posticè ad dorsum subproductâ, marginem ventralem versus truncatâ et sinuatâ.

Shell transversely rhomboido-ovate; anterior end broad, short, and rounded; posterior end broad, a little produced near the back, and diagonally truncated with a small sinus near the ventral margin: a slight depression extending from the umbo to the middle of the ventral margin: valves with fine concentric lines and a few unequal concentric wrinkles.

Length $1\frac{1}{4}$ inch; breadth 2 inches.

Found at Hottentots Kloof, in a light-coloured soft micaceous rock. This is the most abundant of the palæozoic lamellibranchiate species in this collection; of the others there are often but one or two specimens, of this there are above twenty. Two-thirds are separate valves, and one-third consists of specimens having the valves united.

Cleidophorus, Hall.

Gen. Char. An equivalved, inequilateral, lamellibranchiate bivalve, transversely oblong: hinge nearly straight, with numerous small crenulations, extending on both sides of the umbo: ligament external: each valve furnished internally with a strong plate in front of the beak and behind the anterior adductor.

I have followed the authority of Mr. Salter and Mr. Morris in uniting together the genera *Cleidophorus* of Hall and *Cucullella* of M'Coy, which were stated to differ in the former having no teeth in the hinge, and the latter having the "hinge-line entirely crenulated." This is done on the supposition that Mr. Hall's specimens were not in a condition to show the hinge, a case unfortunately only too common among the fossil bivalves from the palæozoic rocks.

Cleidophorus Africanus, Salter, MSS. Pl. XXVII. figs. 2 & 4.

C. testâ transversim elongato-ovali, concentricè inæqualiter subcorrugatâ: laminâ internâ magnâ: cardine recto, dentibus minutis, verticalibus, numerosissimis.

Shell transversely elongato-oval, covered with unequal and irregular concentric lines and wrinkles: internal plate large: hinge straight; teeth small, vertical, and very numerous.

The condition of the specimens does not admit of an accurate description of the external form. This is the largest species yet known of the genus.

Length $1\frac{1}{4}$ inch; breadth $2\frac{1}{4}$ inches.

Found at Cedarberg by Dr. A. Smith, and by Mr. Bain in the dark-coloured schist of Gydow Pass, Bokkeveld, South Africa.

Cleidophorus abbreviatus, Sharpe. Pl. XXVII. fig. 3.

C. testâ transversim triangulato-ovatâ: laminâ internâ maximâ: cardine arcuato; dentibus minutis.

Shell transversely ovate with prominent beaks; anterior and posterior ends regularly rounded: internal plate very large, and nearly reaching to the margin: hinge-line arched; teeth small. The external surface has not been seen.

Length $\frac{3}{4}$ of an inch; breadth 1 inch.

Found at Gydow Pass, in hard dark-coloured schist.

Leda inornata, Sharpe. Pl. XXVII. fig. 5.

L. testâ depressâ, transversim lanceolato-ovatâ, valdè inæquilaterali, concentricè striatâ, anticè rotundatâ, posticè productâ, subacuminatâ.

Shell depressed, transversely lanceolato-ovate, very inequilateral; anterior end broad and rounded; posterior end produced: ventral margin regularly rounded: valves covered with fine concentric lines of growth.

Length $\frac{3}{4}$ of an inch; breadth $1\frac{1}{2}$ inch.

Found at Hottentots Kloof, in a soft light-coloured micaceous sandstone.

Leptodomus? *ovatus*, Sharpe. Pl. XXVII. fig. 7.

L.? testâ transversim ovatâ, anticè abbreviatâ, truncatâ, tumidâ, posticè productâ, rotundatâ, concentricè lineatâ: umbonibus magnis anticis.

Shell transversely ovate; anterior end thick and truncated; posterior end produced and gradually thinning down to the rounded posterior margin: two very slight furrows extend from the beak to the posterior end: beaks large, rounded, and close to the anterior end: valves covered with concentric lines of growth.

Length $1\frac{1}{4}$ inch; breadth $1\frac{5}{8}$ inch; thickness 1 inch.

Found at Leo Hoek.

The specimen does not show sufficient characters to determine the genus.

The slight furrows on the posterior end are not sufficiently shown in the figure.

Sanguinolites? *corrugatus*, Sharpe. Pl. XXVII. fig. 8.

S.? testâ transversim rhomboideâ, medio depressâ, concentricè corrugatâ: umbonibus prominentibus, anticis: carinâ obtusâ, ab umbone ad angulum ventrali-posteriorem extendente.

Shell transversely rhomboidal, with a depression down the middle of each valve, bounded by a broad, obtuse keel, which reaches from the umbo to the posterior ventral margin: beaks prominent and close to the rounded anterior end: valves covered with coarse concentric wrinkles and finer lines of growth.

Length $\frac{1}{2}$ inch; breadth 1 inch; thickness $\frac{1}{2}$ inch.

Found at Leo Hoek, in a nodule of hard dark-coloured siliceous rock.

Having only seen the impression of one pair of valves, a cast of which is figured, I must leave the genus doubtful.

Modiolopsis? Bainii, Sharpe. Pl. XXVII. fig. 9.

M.? testâ subrhomboidali: umbonibus anterioribus: carinâ depresso-rotundatâ, ab umbone ad marginem ventrali-posteriorem, valvam transversè dimidiante: extremitate anteriore truncato-abbreviatâ; posteriore latâ, declivi.

Shell nearly rhomboidal: beaks close to the anterior end: each valve divided into two nearly equal portions by a rounded ridge which reaches from the beak to the ventral-posterior margin: anterior end very short and truncated; posterior end broad and sloping away from the central ridge.

Length 1 inch; breadth 2 inches; thickness $\frac{7}{8}$ths of an inch.

As the generic characters of this shell cannot be seen in the only specimen in the collection, it is placed in the genus *Modiolopsis*, with which its general form corresponds. The cast shows some traces of concentric lines of growth over the whole valve, and of several lines radiating backwards from the beak over the anterior portion.

Found at Leo Hoek.

Anodontopsis? rudis, Sharpe. Pl. XXVII. fig. 10.

A.? testâ subquadratâ, anticè umbonem versus subtruncatâ, medio depressâ, concentricè corrugato-lineatâ: umbonibus medianis.

Shell nearly square: beaks central: anterior side slightly truncated near the beak: posterior side nearly straight: a slight depression down the middle of each valve, reaching to the ventral margin: valves wrinkled with irregular concentric lines of growth.

Length $1\frac{3}{4}$ inch; breadth $1\frac{3}{4}$ inch; thickness $\frac{7}{8}$ths of an inch.

Found at Leo Hoek.

The collection only contains an imperfect specimen of this species, which does not exhibit any characters by which its genus can be correctly ascertained.

Littorina? Bainii, Sharpe. Plate XXVII. figs. 11 & 12.

L.? testâ heliciformi: anfractibus paucis, rotundatis, transversim rugosis: aperturâ rotundatâ, supernè angulatâ.

Shell heliciform; whorls few, rounded, and transversely wrinkled; aperture angular above, rounded beneath.

Largest diameter 1 inch.

Found at Gydow Pass, in dark-coloured schists and nodules.

Fig. 11, a cast, somewhat restored; fig. 12, fragment of a cast.

The specimens are all broken internal casts, too imperfect to allow of a proper description of the species; but, being the only Gasteropod from the formation, they could not with propriety be omitted.

Conularia Africana, Sharpe. Pl. XXVII. fig. 13.

C. testâ pyramidali; lateribus æqualibus, transversim radiatis, medio depressis, angulis rotundatis; radiis binis, æqualibus, arcuatis, junioribus medio laterum interruptis, adultis continuis: radiorum interstitiis lævibus?

Shell pyramidal with equal sides, each of which has a depression down its middle; transverse section nearly rectangular, with the corners rounded off and deeply indented: sides ornamented with numerous parallel projecting ribs, which in the internal cast are formed of two sharp ridges enclosing a rounded furrow (see fig. 13 *b*): the ribs slope upwards from the corners towards the middle of the sides, and in the young shell meet at an angle, cross the mesial depression, and slightly overlap one another; but in older shells they are continuous across the side of the shell in a curve: the interstices between the ribs appear to be smooth?

Found at the Cedarberg, in nodules of dark-coloured rock, weathering ferruginous; in one instance the *Conularia* is associated with casts of *Orthis palmata*.

Fig. 13 *a*, fragment of the internal cast of an old specimen; fig. 13 *b*, enlarged portion of fig. 13 *a*; fig. 13 *c*, section of another specimen, slightly crushed.

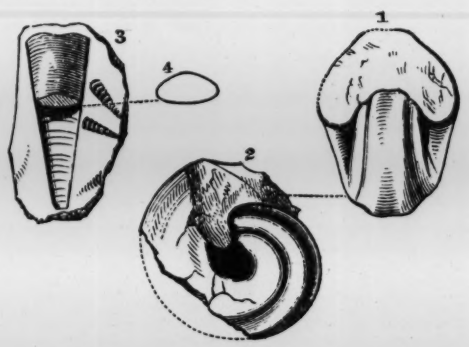
Besides the species above described, the collection contains some imperfect specimens of another species of *Conularia*, which is more nearly related to *C. quadrisulcata* of the Coal-measures of Coalbrook-dale, figured in the Trans. Geol. Soc. 2nd Series, vol. v. pl. 40. fig. 2; but the specimens are not in condition to admit of a good comparison.

There are also a *Bellerophon* and a *Theca*, which have been accidentally omitted in the plates, and of which woodcuts (figs. 1–4) and descriptions have been added by Mr. Salter.

Bellerophon (*Euphemus*) *quadrilobatus*, Salter. Woodcut, figs. 1 & 2.

B. modicus, involutus, umbilico parvo rotundato; anfractibus tumidis 3-lobatis, lobo dorsali multo majore, utrinque rotundato, per medium planato et quasi depresso; aperturâ latâ, lunatâ, utrimque emarginatâ.

Involute, with a very small umbilicus, the edges of which are rounded. Whorls thick, broader than deep, with a concentric sulcus on each side, and with a very broad, flattened, and almost two-



Figs. 1 & 2. *Bellerophon quadrilobatus.*
Fig. 3. *Theca subæqualis*; a portion of the internal cast remaining. (With *Tentaculites.*)
Fig. 4. Transverse section of *Theca subæqualis.*

lobed dorsal margin. Keel probably none. Aperture semilunar, indented on each side above by the sulci, and more than twice as broad as deep. Diameter of the shell $\frac{3}{4}$ of an inch.

This is closely allied to such forms as *B.* (*Euph.*) *trilobatus*, Sow., and *B. bisulcatus*, Röm., from both of which its broad, flattened, and almost double dorsal lobe distinguishes it. There is no appearance of a band; and we think that this group of smooth and but slightly expanded Bellerophons may be distinguished by the subgeneric name formerly applied by Prof. M'Coy (see *Pal. Foss. Cambridge Mus.* p. 308).

Locality.—Warm Bokkeveld.

Theca subæqualis, Salter. Woodcut, figs. 3, 4.

T. conica, compressa, nec trigona; facie dorsali rotundatâ, ventrali lentè convexâ; testâ crassiusculâ? sublævi, striis arcuatis obscuris.

Length $\frac{3}{4}$ inch, width 3 lines. Shell rather thick, quickly tapering, smooth or crossed only by lines of growth; ventral side gently convex, the dorsal more convex and subangular, but with the angles quite rounded off.

It is difficult to distinguish accurately the species of this genus. The present appears distinct from any published. It might have been referred to the *T. lanceolata*, Sowerby and Morris, from New South Wales*, but that species has a more trigonal internal cast, as particularly mentioned by Sowerby, and distinct regular transverse striæ. Both species appear to have had rather a stouter shell than usual in the genus.

Locality.—Occurs as a ferruginous cast, together with *Bellerophon quadrilobatus* and *Tentaculites crotalinus*, in a nodule of dark-grey rock from the Warm Bokkeveld.

Description of Palæozoic Crustacea and Radiata from South Africa.

By J. W. Salter, Esq., F.G.S.

Homalonotus Herschelii, Murchison, Silurian System, pl. 7 bis, fig. 2; Burmeister, Organ. Trilob. (ed. Ray Soc.) p. 87. Pl. XXIV. figs. 1–7.

H. longus, pedalis, spinosus; capite triangulato, fronte in apiculum curvum producto; thorace armato; caudâ convexissimâ, trigonâ, acutâ, annulis sexdecim, nonnullis spinosis.

Of this fossil, which we previously knew only from fragments, Mr. Bain has collected a fine series, showing the upper and under side of the head, with its

* Strzelecki's 'New South Wales,' 1845, p. 289.

curious beak-like process in front, the body-joints in connexion with the tail, and two or three varieties of the tail itself. From the size of fragments which occur with the more perfect specimens, it must have been a very large Trilobite,—probably more than a foot in length. The species is sufficiently distinct from *H. armatus*, figured by Burmeister from the Devonian rocks of the Rhine; it is nevertheless very closely allied to it.

The entire form was elongate, pointed at both ends, and broadest at the base of the head; tapering thence gradually backwards. The head, of which we have good specimens, is convex; the body is also very convex (the fine specimen, fig. 4, has been rather flattened on the middle of the back), and the sides are steeply bent down, so that the entire form was convex and subcylindrical. It was ornamented with large scattered spines along the thorax, the base of the tail, and, in some specimens, even on the head (see the large specimen, fig. 3).

The head is subtriangular and but little rounded on the sides, broader than long in the proportion of thirteen to eight, flattened out in front towards the beak, and highly convex behind, so as to present a triangular outline in a side view (fig. 1*b*). The cheeks are very convex, almost inflated, and bent down so steeply as to appear, when seen from above, much narrower than the glabella;—they are however about the same breadth, and have at their inner margin, close to the base of the glabella, an oval flattened space* (fig. 1*c*).

The glabella itself is urceolate, broadest below, contracted above, and blunt at its well-defined front margin. The basal, middle, and upper lobes show themselves distinctly. It is separated from the prominent neck-margin by a strong furrow, and is bounded in front by the broad concave margin, beyond which the strong curved apiculus projects from the thickened edge. This apiculus is the tubercle† upon the hypostome or rostral shield,—the latter being conspicuous in this species as a triangular large plate beneath the front margin (fig. 2). A similar, but much smaller, tubercle is seen in the hypostome of *Calymene* and of *Encrinurus*.

The facial sutures are very distinct, and there is a marginal suture along the outer edge of the cheeks. The eyes are small, round, and prominent; and are placed on the middle of the very tumid cheeks, less than half-way up the head. The cheeks are not distinctly margined, except posteriorly, where the strong neck-furrow separates a thickened and often spinose margin (figs. 1*a* & 1*b*).

The whole of the head is covered with a strong granulation, which is less conspicuous in the furrows, but is not absent from any part of the upper surface;

* A similar depressed oval space occurs at the same spot in *Illænus Barriensis*. See Memoirs Geol. Surv. Decade 2. pl. 4. fig. 8*a*.

† A double tubercle is seen on the hypostome of a species from the lowest Devonian of the Hartz Mountains. It is the *H. Schusteri* of Römer, Palæontographica, vol. v. t. 3.

even the impressed oval space (fig. 1 *c*) is granulated. The hypostome is smooth, or nearly so; but the beak is rough.

We have two perfect specimens of the body and many fragments. Each of the thirteen rings is convex, almost subcylindrical in its posterior portion, and has generally one large spine on each side at a short distance *within* the fulcral point (see fig. 1), and none on the pleuræ. In other varieties, however, (fig. 5) two spines occur on each side, both within and beyond the fulcrum, and scattered spines appear on the middle part of the axis; but these are rare exceptions. The fulcrum is but slightly marked, and placed far outwards; and beyond it the pleuræ slope gently outwards for a short distance and then bend abruptly down at a right angle, with a wide and strong facet. Fig. 5. Pl. XXIV. represents these pleuræ flattened out by pressure; their true form is indicated in the figure of a more perfect specimen, fig. 4.

The specimen illustrated by fig. 6, if not a distinct species, is at least a very remarkable variety, with broader segments more deeply trilobate,—the trilobation taking place *within*, and not *at*, the fulcral point. It is probably a distinct species.

The length of the body is not twice that of the tail, and it is rather flattened down the middle. The anterior segments are much arched backwards at their extremities, and the tips of all the pleuræ are broad, rounded, and recurved.

The tail is long-triangular, longer by one-fifth than the width, and so convex that the depth is nearly equal to the width. The axis is highly arched, not so wide as the sides, which are almost vertical, and scarcely marked off at all from them. The tail of the young animal (fig. 8) is shorter and broader, and has fewer ribs.

The ribs are all continuous across. There are sixteen or seventeen on the axis of our largest specimen; and the front seven or eight of these have tubercles on each side, and a few tubercles also down the middle. About ten or eleven show themselves distinctly on the sides; but the lowest ones are faint, and more arched forwards than the rest. A few only of the upper ones bear any tubercles at the base. Occasionally there are more tubercles.

The apex is blunt-pointed, and a little abruptly produced from the tip of the axis, which reaches nearly all the way down.

The incurved margin (fig. 7 *c*) is not broad; and, like the whole of the upper surface of the tail, is rough with granulations. The anterior facet (see fig. 7 *b*) is large and sharply defined.

This species differs at a glance from the related species *H. armatus*, Burm., in the much larger glabella and broader axis of the body. The tail, in proportion to the body, is twice as long; has double the number of rings; and ends in a blunt short point; while in *H. armatus* it is a prolonged spine. Nor do we know of any other published species of at all similar character, except *H. Pradoanus*, De

Vern., from Spain, which has a roughly tubercular body, a rounded and not highly convex tail, and fan-like side ribs, spinous near their ends; the axis is roughly tubercular, as well as spiny. There is indeed no near resemblance. Both the last species belong to a group of *Homalonoti* only known in the Lower Devonian rocks.

The quotation of this species from the Rhenish rocks, by D'Arch. and De Vern. (Trans. Geol. Soc. 2nd Ser. vol. vi. p. 381), is erroneous. *H. armatus*, Burm., is intended. And there is some mistake in Dr. Sandberger's supposing that the *H. Knightii*, Sow., had been identified by De Verneuil as from these rocks. The South African specimens are all of one, or at most two, species, neither of them identical with European forms.

Localities.—In black and grey hard schists, in light-coloured softer micaceous rock, and in dark-coloured nodules, weathering ferruginous, at Gydow Pass and at Leo Hoek; and in ferruginous nodules and light-coloured argillaceous schists in the Warm Bokkeveld.

Next to the *Homalonotus*, the commonest Trilobite is a new species of *Phacops*, —of the section *Cryphæus*:—it is the

Phacops (*Cryphæus*) *Africanus*, sp. nov. Pl. XXV. figs. 1–9.
Calymene Blumenbachii, Murchison, Sil. Syst. p. 654.

P. 2–5-uncialis, convexus; axi quam lateribus latiore; capite subtrigono; oculis parvis; glabellâ productâ subparallelâ, sulcis sinuosis, basali profundiore lunato sursum curvato; caudâ laciniis utrimque quinque robustis, et mucrone centrali brevi lato; axi obtuso, 6–7-annulato.

The species is in general found of 2–3 inches long, as shown in our figures 2, 6, and 9, and at that age may be easily recognized by its convex form, sharp-pointed pleuræ, and spinose tail. It is unlike the generally depressed form of the subgenus to which it belongs, and which it connects with the ordinary forms of *Phacops* (*Acaste*, Goldf.). The head is nearly a right-angled triangle; the length nearly two-thirds the width. The glabella is blunt-pointed, and is much broader than the sloping cheeks, and divided from them by only shallow parallel furrows. The glabella-furrows are as follows:—the upper one sigmoid, and extending above the eye; the second short, arched down, and recurved at the tip; the basal one deeper, longer, and arched upwards; neck-furrow strong, and much arched upwards in the middle. The neck-segment is convex and has a central spine. Posterior head-angles short, spinous (fig. 8); eye small, lunate, rather prominent, placed near the glabella and more than half-way up the cheek; (it is not represented far enough forward in fig. 6, *b*). Surface of head smooth? Facial suture very forward at its outward termination.

The axis of the thorax is nearly parallel-sided, very convex, and rather wider than the sides, which are curved steeply downwards at a short distance from it. The fulcrum is at less than one-third in front, and much closer behind; and the tips of the nearly direct pleuræ have sharply recurved points (see fig. 9). The axis in some specimens (fig. 3) has blunt spines along the middle,—it is difficult to say if this be general or not, as most of our specimens are internal casts.

The tail is rounded and convex; its outline is arched in front; the axis prominent, especially at the blunt tip, somewhat conical, and reaching nearly to the margin; it has six distinct rings; the sides have four or five distinct furrows, which do not reach the margin; they are faintly interlined on the outer portion; the edge is serrated,—five teeth on each side, and a short obscure terminal lobe. (The margin is not sufficiently rounded in our fig. 4.)

The form nearest akin to this species is perhaps one from the summit of the Andes, described by M. D'Orbigny, and of which, through his kindness and that of Mr. Pentland, we have been able to compare the specimen. This rare fossil, the *Phacops* (*Calymene*) *Verneuilii*, D'Orb., differs, however, in some essential points. It has a wider glabella, and the two lower pairs of furrows do not form an oval as in *P. Africanus*, but are short and direct. The pleuræ are spinose, as in ours; but the tail has much fewer (two or three) ribs on the axis, and the same number on the sides. The specimen does not show the margin of the tail.

I have little doubt that the *Calymene Tristani*, quoted by D'Archiac and De Verneuil from the Cedarberg Mountains (Trans. Geol. Soc. 2 Ser. vol. vi. p. 381), was a crushed individual of this or of the following species. The *Calymene Blumenbachii* of the same list was identified from our figured specimen, fig. 9. It is rather remarkable that De Koninck should lay stress upon it as the "true species."

Localities.—In light-coloured soft micaceous rock, black schists, and ferruginous nodules, at Gydow Pass; in light-coloured soft rock and hard dark schist, at Hottentots Kloof; and in dark-coloured schist and nodules, at Cedarberg. It is associated with *Orthis palmata* in one specimen from Gydow Pass.

The specimens illustrated by figs. 6, 7, and 9 were collected by Dr. A. Smith in the Cedarberg, and were presented by Sir R. I. Murchison to the Museum of Practical Geology.

Phacops Caffer, sp. nov. Pl. XXV. figs. 10–13.

P. ferè 4-uncialis, subdepressus, axi quam lateribus latiore; capite transverso granulato; fronte apiculato; oculis majoribus; glabellâ subparallelâ, sulcis radiatis rectis æqualibus, lobis convexis; caudæ axi conico, haud elevato, multi-annulato; margine spinoso.

This species when perfect must have been 4 inches long, judging from the

proportions of the head to the body in the smaller perfect specimens. It is much less convex than the species last described; it has larger eyes, and swelled lobes to the glabella (figs. 10 & 11); and both the pleuræ and tail had probably much shorter spines. Head somewhat semicircular, rounded in front, with a small blunt apiculus, and nearly twice as wide as long. The glabella is wider than the cheeks and distinctly divided from them; it is convex, wider in front; the furrows are radiating, and straight, compared with those of the last species; the middle and basal ones only arching a little towards each other. Posterior head-angles rounded. Eyes large, conical (fig. 12), placed nearly on the middle of the cheeks, which are pitted in a radiate fashion.

The glabella is covered with small scattered granules (not shown in our figure), mixed with larger ones on the forehead-lobe.

Thorax granulose, gently convex, the axis about as wide as the pleuræ, the joints slightly tubercular at the sides, but not elevated in the middle. The fulcrum is in the same position as in the last species, and the pleuræ are pointed, but do not curve down steeply.

The tail is semicircular and but little convex; the axis of five distinct and three obscure ribs, rapidly conical and pointed, not blunt or prominent, at the apex. The sides have six strong lateral furrows (including the articular one), distinctly interlined; but the strong furrows do not reach the margin. The edge is spinose, but too imperfect for its characters to be ascertained.

Localities.—In dark-coloured and greenish-grey schists and light-coloured softer rocks at Gydow Pass; and in ferruginous nodules at Gydow Pass and Leo Hoek.

Phacops; sp.

There are perhaps two more species of *Phacops* in Mr. Bain's collection.

No. 1, represented by a caudal shield, is certainly distinct. The specimen is short-triangular, and has a *very prominent* blunt axis, with seven distinct ribs,—even nine in a large specimen. The sides slope rapidly away from it, and are obscurely marked; with about five side-ribs, faint in the cast, not sharp and distinct as in *P. Africanus.* The axis seems to be as broad as in that species.

Locality.—In black schist at Gydow Pass.

No. 2.—Of the other species we have only one specimen, and that consisting of the thorax only, which has the axis *much narrower* than the pleuræ.

It is in a light-coloured argillaceous rock from Leo Hoek.

No. 3.—A specimen, which may belong to one or other of these two species. The head differs from that of *P. Africanus* in the following particulars:—

It is longer in proportion to the width, and the glabella is blunt and rounded in

front. The furrows are equal in strength, and the upper one straight instead of sigmoid; and there is a central pit in the large forehead-lobe. The pleuræ are strongly facetted. The axis not very convex. These characters will enable future observers to recognize it in better specimens.

Locality.—Gydow Pass, in a soft argillaceous sandstone.

Typhloniscus, genus nov.

Body elongate, distinctly trilobed, 10?-ringed, with strongly bent and facetted pleuræ, produced into short spines. Glabella with radiating furrows, the forehead-lobe produced. Cheeks scrobiculate, entire. Eyes and facial suture none. A distinct rostral shield beneath. Tail consisting of few segments; the pleuræ free at the ends.

Typhloniscus Bainii, sp. nov. Pl. XXV. fig. 14.

T. 2½-uncialis; glabellâ depressâ, sulcis æqualibus; pleuris quam axi latioribus; pygidio utrimque quadrilobo.

So much has this the appearance of *Placoparia*, a Lower Silurian genus found in Spain and Bohemia, that one is at first tempted to believe it must have been derived from different strata to those in which the other Trilobites above-described occur. There is the same radiating arrangement of the glabella-furrows as in *Placoparia*; and the same triangular scrobiculate and margined cheeks, on the forward angle of which the eye, minute if it existed at all, was placed: and there are the abruptly-bent pleuræ and an obtuse many-lobed tail. In all these points there is the closest resemblance. But there are also some differences of importance. The front lobe of the glabella is larger and produced forwards (not truncate), and the place of the eyes, if there were any, is indicated only by a tubercle at the extreme front of the cheek, and this is subtended by no transverse furrow like that of *Placoparia*. There appears to have been really *no* facial suture, and probably only a minute eye.

Then again, the pleuræ, though abruptly bent down, are furrowed, not nodular, as in *Placoparia*, and their distal ends are bent backwards as well as downwards. There were probably fewer body-rings than in the latter genus,—ten instead of twelve: this however is uncertain.

If the above characters separate it from *Placoparia*, there is no section of *Cheirurus* with which it can be closely compared; though it is nearer to *Eccoptochile* than to the rest. Especially does it differ from the Devonian type of the genus (*Crotalocephalus*, Salter), in which the furrows run right across the glabella, and the eyes are well developed.

Locality.—In a dark schist from Gydow Pass.

Annelida.

Two species only—one belonging to *Serpulites* and the other to *Tentaculites*—have been yet observed. The latter is abundant; and is in all probability the species referred to by Dr. Sandberger, who identifies it with the *T. annulatus* of the Rhenish provinces.

Tentaculites crotalinus, sp. nov. Pl. XXV. figs. 15–18.

T. uncialis, testâ tenui, intus vix annulatâ, annulis externis rectis transversis, primùm crebris; dein validis remotioribus, striis interstitialibus ferè nullis; apice lævi.

Rather a small species; three-quarters of an inch in length and about a line thick; slowly tapering and with nearly direct prominent rings, very variable in distance from one another, but always more than their diameter apart in the older portions. In the younger parts the rings are closer and less prominent, and the apex is frequently bare of them for a variable space (fig. 16). At other times the young tube is closely annulated nearly to the tip, but there is always some irregularity in the rings there, and there are some intermediate striæ (fig. 18). The latter are very rare indeed among the older rings; one or two are represented in fig. 16.

Fig. 17 shows the internal cast; it has scarcely any trace of the rings which are so conspicuous in *T. annulatus* of the Rhenish rocks*. That species too (and its internal cast, *T. scalaris* of Schlotheim) is larger; and its rings are a little oblique,—a frequent character in the genus.

There is a beautiful Tentaculite in the Devonian rocks of Armenia, which has been shown to us by Prof. Abich, and which is a good deal like the *T. crotalinus*; but it has a thick shell, and striæ between the rings.

Localities.—In a nodule of hard dark-grey rock, exhibiting ferruginous casts of *Tentaculites*, *Bellerophon*, &c., from the Warm Bokkeveld. The *Tentaculites* also occur in the light-coloured micaceous rock of the Hottentots Kloof, together with *Solenella rudis*.

Serpulites Sica, sp. nov. Pl. XXV. fig. 19.

S. calcareus, unciam longus, compressus, lentè curvatus, striis obliquis.

There are not many available characters in the smooth shelly envelopes of Annelids. The specimens before us, however, are a group of short tubes about an inch long, compressed laterally, and curved like the sheath of an Indian dagger. The striæ of growth are conspicuous and oblique, retreating from the inner curve of the tube.

Locality.—In dark-coloured schist, Warm Bokkeveld.

* The species termed "T. annulatus" in the "Silurian System," and indeed in all British works on Silurian fossils, has *longitudinal* striæ, and is clearly distinct. It should be called *T. anglicus*.

Echinodermata.

Remains of *Crinoidea* are so abundant in Mr. Bain's collection as to promise to future observers a rich harvest of species. The specimens sent to England by Mr. Bain are from the Warm Bokkeveld and Kokman's Kloof *. It would of course be idle to give names to the numerous varieties of stems and joints (Pl. XXV. figs. 21–28), unless the bodies to which they belong had been determined. They much resemble those of *Rhodocrinus*, as figured by Goldfuss.

There is one tolerably perfect species, however, which we dedicate to the late Dr. Stanger, who brought it to England on his last visit. We are obliged to propose a new genus for it.

Ophiocrinus Stangeri, nov. gen. et sp. Pl. XXV. fig. 20.

The calyx is cup-shaped, and rather wider than high, with prominent radial and brachial pieces, somewhat depressed inter-radial areas, and twenty simple arms a little longer than the calyx. We have only three rays and two inter-radial areas, one lateral and one anal (?).

The stem is stout, consisting of alternating thick and thin rings (fig. 23 may very possibly belong to it). The five† basals are prominent, overhanging the stem, hexagonal, and alternating with the pentagonal first radials.

Radial pieces broader than long, three in the two posterior rays,—five in the other (antero-lateral?) ray. Brachials of similar size; two and three in the posterior arms, three in the antero-lateral.

Inter-radial spaces filled with numerous, twenty to thirty, hexagonal pieces; the upper ones very small, the lower two or three nearly as large as the radials. Interbrachial pieces eight or nine, very small.

Arms simple, cylindrical, consisting of a single series of wedge-shaped joints.

* Encrinital remains (or impressions of joints and stems) are common in the dark schists of the Gydow Pass, and in the rock which abounds with *Orthis palmata* (from the Cold Bokkeveld). A specimen of *Phacops Africanus* from the Cedarberg, collected by Dr. A. Smith, is also associated with Encrinital casts.

The Editor has lately received from the Cape of Good Hope a few portions of Encrinital stems (in a ferruginous condition, similar to some in Mr. Bain's collection, but differing from the figured specimens), which were picked up by a soldier of Sir G. Cathcart's army, near the most easterly branch of the Orange River. The Encrinital remains are associated with ferruginous casts of small turrited shells, with fragments of agates, quartz, and fossil wood, and with crystals of mundic.

Amongst some gravel, collected twelve years ago near the mouth of the Orange River, and sent to the Editor at the same time with the above, another fragment of Encrinital stem occurs. This is also ferruginous and resembles one of the above-mentioned specimens. The gravel contains agates, siliceous rocks, black schist, and copper-ore.

† Goldfuss, Nova Acta Acad. Curios. vol. xix. 1838; Petref. Germ. vol. i. p. 193.

They are convex and bear pinnæ alternately on each side,—the lower joints are transverse and flatter.

I should have thought this to have been a *Rhodocrinus*, although it has more brachial pieces, and even more radials on the anterior rays; but that genus, besides having an equal number of radial pieces in all the rays, is characterized as having compound arms; our genus has simple arms and unequal radii. It is, however, a close ally of *Rhodocrinus*; and I cannot help thinking, with M. Römer, that the five large pieces which in that genus, as in ours, alternate with the first radials are the true basal or *pelvic* pieces (see Goldfuss's figure of *Rhod. crenatus*, Petref. Germ. vol. i. pl. 64. fig. 3).

As we have but one species, and that not quite complete, it was thought better to give a full description rather than a generic character.

The original specimen is a very complete intaglio in dark-coloured sandstone, in the collection of the late Dr. Stanger. The exact locality is not known; but the specimen was accompanied by *Homalonotus Herschelii*. Fig. 20 *a* is taken from a gutta-percha cast.

Conclusion.

It will be seen by the palæontological reader, that, of the twenty-seven species here described, all, with two exceptions, belong to genera known in Devonian strata, and some of them to forms of those genera peculiarly characteristic of such rocks. This is especially to be noted in the case of the broad-winged *Spiriferi*,—the spinose *Homalonoti*,—the fan-tailed species of *Phacops*,—and the *Tentaculites*, which looks so like *T. annulatus* of the Rhenish Provinces, that it has been identified as such.

In no other formation can such an association as of the above forms with species of *Cucullella*, *Bellerophon*, *Conularia*, *Chonetes*, and *Strophomena*, be discovered; and hence, in the absence of any true Silurian species, or even of any purely Silurian genus, we are compelled to regard the formation as Devonian.

Of the two undescribed genera, one (*Typhloniscus*) is a remarkable Trilobite, so closely resembling a Lower Silurian genus, that it was long before its true characters were made out. Yet, when closely examined, it turns out to be one of the many forms of the family *Cheiruridæ*,—a group especially abundant at or near the base of the Devonian system.

The other, a Crinoid, which we have called *Ophiocrinus*, is more nearly related to Devonian forms of *Rhodocrinus* than to any other. These genera do not therefore invalidate the above conclusion.

Notes on some Fossils from the Karoo Desert and its Vicinity. By Daniel Sharpe, Esq., F.R.S., Pres. G.S., Dr. Hooker, F.R.S., F.G.S., and Sir P. De M. Grey Egerton, Bart., M.P., F.R.S., F.G.S.

Fossils from the Karoo Series, South Africa.

Iridina? rhomboidalis, *Sharpe.* Pl. XXVIII. fig. 2	Graaf Reinet.
Iridina? ovata, *Sharpe.* Pl. XXVIII. figs. 3 & 4	Graaf Reinet.
———? Pl. XXVIII. fig. 5	Graaf Reinet.
———? Pl. XXVIII. fig. 6	Graaf Reinet.
Cyrena? Pl. XXVIII. fig. 7	Graaf Reinet.

Note.—The above-mentioned fossils are in a ferruginous sandstone from Graaf Reinet (in the Collection of the Geological Society); they are referred with some doubt to freshwater genera, and are not associated with any marine species.—[D. Sharpe.]

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18-8, 227/1

Asterophyllites? Pl. XXVIII. fig. 1	Roggeveld (Fish River).
Fossil Wood and Plant-remains	*passim*.
Palæoniscus Bainii, *Egerton.* (Scales.) Pl. XXVIII. figs. 26, 27, 31, 33, 34, 37, 38	Styl Krantz.
——— sculptus, *Egerton.* (Scales.) Pl. XXVIII. figs. 28, 29, 30, 32, 35, 36, 39, 40	
——— (Scales.) Pl. XXVIII. figs. 41, 42	
Ichthyolites (undeterm.)	Brak River, Fort Beaufort.
Dicynodon lacerticeps, *Owen.* Pl. III., Pl. IV., p. 62 . . .	Beaufort, Blinkwater, Tarka, Styl Krantz, and Modder River (*D. testudiceps*).
——— testudiceps, *Owen.* Pl. V., Pl. VI. fig. 1, p. 71 . .	
——— strigiceps, *Owen.* Pl. VI. figs. 2 & 3, p. 75 . . .	
——— Bainii, *Owen.* p. 76	
——— tigriceps, *Owen.* Plates XXIX.–XXXIV. p. 223 . .	

Description of some Remains of Mollusca from near Graaf Reinet.
By Daniel Sharpe, Esq., F.R.S., Pres.G.S.

Iridina? rhomboidalis, Sharpe. Pl. XXVIII. fig. 2.

I.? testâ transversim rhomboidali, anticè subrotundatâ, posticè truncatâ: margine ventrali recto: lineâ cardinali subarcuatâ, dentibus 15 parvis, verticalibus, uniseriatis, inæqualibus.

Shell transversely rhomboidal; anterior end somewhat rounded, posterior end truncated; ventral margin straight: hinge-line curved with about fifteen small,

unequal, vertical teeth, closely set in one series. (Only an internal cast has been seen.)

Length $\frac{1}{3}$ inch; breadth $\frac{3}{4}$ inch.

Found at Graaf Reinet. (From the Geological Society's Collection.)

Fig. 2*a*, hinge-line of 2*b*. Fig. 2*b*, internal cast of the right valve (reversed in the plate).

Iridina? ovata, Sharpe. Pl. XXVIII. figs. 3 & 4.

I.? testâ transversim ovatâ, anticè rotundatâ, posticè productâ et obliquè truncatâ, concentricè rugulosâ: margine ventrali medio depresso: umbonibus prominentibus: lineâ cardinali arcuatâ, dentibus 12 parvis, verticalibus, uniseriatis.

Shell transversely ovate; anterior end rounded; posterior end somewhat produced and obliquely truncated; middle of the ventral margin slightly depressed: valves ornamented with numerous unequal concentric wrinkles: umbones prominent: hinge-line arched with about twelve small vertical teeth, closely set in one series.

Length $\frac{1}{2}$ inch; breadth $\frac{8}{10}$ inch.

Found at Graaf Reinet. (From the Geological Society's Collection.)

Fig. 3, an internal cast, with teeth like those of fig. 2*a*: left valve (reversed). Fig. 4, exterior, somewhat restored: left valve (reversed).

Note on the Fish-remains from Styl Krantz, South Africa.

By Sir P. De M. Grey Egerton, Bart., M.P., F.R.S., F.G.S. &c.

[Plate XXVIII. figs. 26–42.]

I have examined the fish-remains forwarded by Mr. Bain to the Geological Society from South Africa. The materials are very scanty, as the specimens only exhibit scattered scales; but I am inclined to believe that they are all referable to the genus *Palæoniscus*.

If I am correct in this inference, the characters of the individual scales indicate two species, both of which appear to be new:—one having the surfaces of the scales profusely ornamented with sinuous grooves, and their posterior margins deeply incised,—the other having the surfaces comparatively smooth, and the posterior margins only slightly serrated.

The specimens figured 41 and 42 of the plate are from the series of elongated, imbricated, fulcral scales covering the base of the upper lobe of the tail.

If provisional names are advisable until further evidence is obtained, the former may be designated *Palæoniscus sculptus*; the latter, *Palæoniscus Bainii.*

Figs. 26, 27, 31, 33, 34, 37, 38, belong to *P. Bainii*; figs. 28, 29, 30, 32, 35, 36, 39, 40, belong to *P. sculptus*; figs. 41, 42, imbricated scales from the upper base of the tail.

The figures represent the specimens magnified two diameters.

P. M. Grey Egerton.

Note on a Fossil Plant from the Fish River, South Africa.

By J. D. Hooker, M.D., F.R.S., F.G.S. &c.

[Plate XXVIII. fig. 1.]

The remarkable fossil discovered by Mr. Bain in the Roggeveld (Fish River), and figured on Plate XXVIII., presents no resemblance to any plant with which I am acquainted; and, though the specimens are in excellent condition, I am wholly unable to suggest a probable affinity for them. The general appearance of the plant is that of an elongated stem, giving off at intervals whorls of linear, lanceolate, blunt leaves. These leaves are seven or fewer in a whorl; are all united at the base; are of unequal length and breadth; and are marked with six to ten straight, undivided, unbranched, free ribs or veins, with intervening narrow grooves; in this respect resembling the leaves of some American *Cycadeæ*, and of some *Coniferæ*, as *Dammara* and *Podocarpus latifolius*.

Mr. Bain has found some truncated conical bodies, not unlike the bases of stems, in a position that appears to indicate the probability of their having been the bases of the stems of this fossil; but they do not present any characters of structural or systematic importance.

I have shown the specimens to many of my botanical friends, amongst others to one well-versed in fossil botany also (Dr. Lindley), but none of them are able to suggest any plausible affinity amongst living plants.

Joseph D. Hooker.

Note.—Whilst this sheet was passing through the press, an opportunity was afforded, by the kindness of Col. Portlock, of examining a small series of fossil plants forwarded by Mr. R. N. Rubidge from the Dicynodon-strata of Smithfield, Orange River Sovereignty. In Mr. Morris's opinion, these fossils are essentially "Secondary" in character, from the preponderance of the remains of *Cycadeæ*, and probably represent a Triassic or a Jurassic flora.—Edit.

EXPLANATION OF PLATES XXII.—XXVIII.

Plate XXII.

Fig. 1. *Pinna Atherstoni*, Sharpe. From Sunday River. p. 193.
1 *a*. Cast, with some of the shell remaining.
1 *b*. Transverse section of the anterior part.
Figs. 2 & 3. *Modiola Bainii*, Sharpe. From Sunday River. p. 193.
2. Fragment of a large specimen.
3 *a*. Fragment of a young shell.
3 *b*. Transverse section of fig. 3 *a*.
Fig. 4. *Perna Atherstoni*, Sharpe. From Geelhoutboom, Sunday River. p. 193.
4. Left valve.
4 *a*. Interior of the right valve of another specimen.
4 *b*. Anterior side of fig. 4.
Fig. 5. *Trigonia Vau*, Sharpe. From Sunday River. p. 194.
Figs. 6 *a* & 6 *b*. *Pholadomya Dominicalis*, Sharpe. From Sunday River. p. 194.
Figs. 7 *a* & 7 *b*. *Myacites*? *Bainii*, Sharpe. From Sunday River. p. 195.
Fig. 8. *Ceromya papyracea*, Sharpe. From Zwartkop River. p. 195.
Fig. 9. *Cyprina rugulosa*, Sharpe. From Zwartkop River. p. 195.
9 *a*. Exterior of the left valve.
9 *b*. Hinge of the left valve.
Fig. 10. *Arca Atherstoni*, Sharpe. From Sunday River. p. 196.
Fig. 11. *Psammobia Atherstoni*, Sharpe. From Sunday River. p. 196.
11 *a*. Cast of the impression of the left valve.
11 *b* & 11 *c*. Internal cast.

Plate XXIII.

Figs. 1 *a* & 1 *b*. *Ammonites Atherstoni*, Sharpe. From Sunday River. Reduced to two-thirds its diameter. p. 196.
Figs. 2 *a* & 2 *b*. *Ammonites Bainii*, Sharpe. From Sunday River. p. 197.
Fig. 3. *Gryphæa imbricata*, Krauss sp. From Sunday River. p. 197.
3 *a*. Side view of the valves united. 3 *b*. Exterior of the upper valve.
Fig. 4. *Gastrochæna Dominicalis*, Sharpe. From Sunday River. p. 198.
4 *a*. Fragment of wood* perforated by *Gastrochænæ*.
4 *b*. Dorsal view of the valves, magnified two diameters.
Fig. 5. *Neritopsis*? *turbinata*, Sharpe. From Sunday River. p. 198.

Plate XXIV.

Homalonotus Herschelii, Murchison. p. 215.

Fig. 1 *a*. The head, with the crust preserved. From Leo Hoek.
1 *b*. The same specimen, side view.
1 *c*. The oval space beneath the eye; magnified, to show that it is granulated like the rest of the head.

* This is by mistake described as "bone" at p. 198.

Fig. 2. Under-side of the head of another specimen; the crust lost: the rostral shield, with the projecting tubercle, and the suture along the *margin* of the cheek, are well seen here: the suture is visible also in fig. 1*b*. From Leo Hoek.

Fig. 3. Outline of the head of a very large specimen. This variety has spines on the lower glabella-lobes. From the Warm Bokkeveld.

Fig. 4. Entire body and tail of a specimen with but few tubercles. From Gydow Pass.

Fig. 5. Two segments of the body of a many-spined variety. From Gydow Pass.

Fig. 6. A segment broader, in proportion to the width, than usual, and trilobed further inward; probably belonging to a distinct species. From the Warm Bokkeveld.

Fig. 7 *a*. A fine tail of a moderately spiny variety. From Leo Hoek.

7 *b*. A side view of the same, showing the large facet.

7 *c*. The incurved under portion of the tail.

7 *d*. A portion of the surface, magnified.

Fig. 8. The tail of a young individual; without spines. From Gydow Pass.

Plate XXV.

Fig. 1. *Phacops Africanus*, Salter; p. 218: a specimen of the largest size, with the crust removed. From Gydow Pass.

Fig. 2. Body and tail of another specimen; the axis is rather depressed, so as to appear broader than it really is. From Gydow Pass.

Fig. 3. Segments of a specimen, with dorsal spines on each segment. From Hottentot's Kloof.

Fig. 4. Tail of the same species. From Hottentot's Kloof.

Fig. 5. Head of the same species; showing the elevated eye. From Gydow Pass.

Fig. 6. Head of the same species. Cedarberg. (Mus. Pract. Geology.)

6 *a*. Seen from above. 6 *b*. Side view.

Fig. 7. Under-side of head of the same specimen.

Fig. 8. A small head, showing the lateral spines very perfectly. From Gydow Pass.

Fig. 9. Body of an individual belonging to the same species. Cedarberg. (Mus. Pract. Geology.)

9 *a*. Side view. 9 *b*. View of the caudal extremity.

9 *c*. Some body-rings, with the curved and spinose pleuræ.

Fig. 10. *Phacops Caffer*, Salter, young. p. 219. Head. From Gydow Pass.

10 *a*. Side view. 10 *b*. Seen from above.

Fig. 11. The head of a much larger specimen. From Leo Hoek.

Figs. 12 *a* & 12 *b*. The eye of the same specimen, magnified.

Fig. 13. Nearly perfect specimen of the same species. From Gydow Pass.

Fig. 14 *a*. *Typhloniscus Bainii*, Salter; p. 221.

14 *b*. One of the body-segments, with the terminal spine [the latter is too long in the drawing].

Fig. 15. *Tentaculites crotalinus*, Salter; p. 222; nat. size. From the Warm Bokkeveld.

Fig. 16. External shell, magnified.

Fig. 17. Internal cast, magnified.

Fig. 18. Portion of a variety, with more rings in the youngest portion; magnified.

Fig. 19 *a*. *Serpulites Sica*, Salter; p. 222.

19 *b*. A specimen magnified. From the Warm Bokkeveld.

Fig. 20. *Ophiocrinus Stangeri*, Salter; p. 223; enlarged to twice the size: the line indicates the natural length: at *a*, some of the wedge-shaped arm-joints are magnified.

Figs. 21–28. Various stems of *Encrinites*, very characteristic of these strata. p. 223. They appear to be allied to those of *Rhodocrinus*. From the Warm Bokkeveld and Kokman's Kloof.

Plate XXVI.

Figs. 1, 2, & 5. *Spirifer Antarcticus*, Morris and Sharpe. p. 206.

1. Dorsal valve, interior.
2. Ventral valve, interior.
5. Dorsal valve, exterior.

Figs. 3, 4, & 6. *Spirifer Orbignii*, Morris and Sharpe. p. 207.

3. Dorsal valve, interior.
4. Ventral valve, interior.
6. Ventral valve, exterior.

Figs. 7–10. *Orthis palmata*, Morris and Sharpe, sp. p. 207.

7. Ventral valve, exterior.
8. Dorsal valve, exterior.
9. Ventral valve, interior.
10. Dorsal valve, interior.

Figs. 11 & 12. *Terebratula Bainii*, Sharpe. p. 208.

11. Ventral valve, exterior.
12 *a*. Ventral valve, interior.
12 *b*. Dorsal valve, exterior.

Figs. 13 & 17. *Strophomena Bainii*, Sharpe. p. 208.

13. Ventral valve, exterior.
17. Dorsal? valve, exterior.

Figs. 14, 15, & 16. *Chonetes*, undetermined. p. 209.

Figs. 18 & 19. *Strophomena Sulivani*, Morris and Sharpe, sp. p. 209.

18. Ventral valve.
19. Dorsal valve.

Figs. 20–23. *Orbicula Bainii*, Sharpe. p. 210.

20 *a* & 20 *b*. Upper valve of a small specimen.
20 *c*. Part of the surface of 20 *a*, magnified.
21 *a* & 21 *b*. Upper valve of a large specimen, which has lost nearly the whole of the shell.
22. Lower valve.
23. Fragment of upper valve, with the shell well preserved.

Plate XXVII.

Fig. 1. *Solenella antiqua*, Sharpe. p. 210.

1 *a*. Right valve.
1 *b*. Hinge of 1 *a*.

Figs. 2 & 4. *Cleidophorus Africanus*, Salter, MSS., p. 211.
2. Left valve, with the surface partially preserved.
4. Hinge-line of an imperfect specimen of both valves.
Fig. 3. *Cleidophorus abbreviatus*, Sharpe. Internal casts of both valves, p. 212.
Fig. 5. *Leda inornata*, Sharpe, p. 212.
Fig. 6. *Solenella rudis*, Sharpe, p. 211.
Fig. 7. *Leptodomus? ovatus*, Sharpe, p. 212.
Fig. 8. *Sanguinolites? corrugatus*, Sharpe, p. 212.
Fig. 9. *Modiolopsis Bainii*, Sharpe, p. 213.
9 *a*. Cast of left valve.
9 *b*. Dorsal view of 9 *a*.
Fig. 10. *Anodontopsis? rudis*, Sharpe, p. 213.
Figs. 11 & 12. *Littorina? Bainii*, Sharpe, p. 213.
Fig. 13. *Conularia Africana*, Sharpe, p. 214.
13 *a*. Fragment of natural size of an internal cast.
13 *b*. Portion of 13 *a*, magnified.
13 *c*. Section of another specimen.

Plate XXVIII.

Fig. 1. Fossil plant; natural size. From the Roggeveld. p. 227.
Fig. 2. *Iridina? rhomboidalis*, Sharpe. From Graaf Reinet. p. 225.
2 *a*. Hinge-line; magnified.
2 *b*. Internal cast of valve; nat. size.
Figs. 3 & 4. *Iridina? ovata*, Sharpe. From Graaf Reinet. p. 226.
3. Internal cast; nat. size.
4. Exterior, somewhat restored; nat. size.
Fig. 5. Undetermined shell; nat. size. From Graaf Reinet.
Fig. 6. Undetermined shell; nat. size. From Graaf Reinet.
Fig. 7. *Cyrena?*, internal cast; nat. size. From Graaf Reinet.
Fig. 8. *Cyrena?*, magnified 6 diameters. From Zwartkop.
Fig. 9. *Cyrena?*; magnified 8 diameters. From Zwartkop.
Fig. 10. *Avicula Bainii*, Sharpe, left valve; magnified 3 diameters. From Zwartkop. p. 199.
Fig. 11. *Modiola Atherstoni*, Sharpe; magnified 3 diameters. From Zwartkop. p. 199.
Fig. 12. *Sanguinolaria? Africana*, Sharpe; p. 199. From Zwartkop.
12 *a*. Internal cast of the left valve (reversed by the artist); magnified 3 diameters.
12 *b*. External markings, magnified, of another specimen.
Fig. 13. *Cyrena? Bainii*, Sharpe; natural size. From Zwartkop. p. 199.
Fig. 14. *Trochus Bainii*, Sharpe; magnified 12 diameters. From Zwartkop. p. 199.
Figs. 15 & 16. *Turbo Atherstoni*, Sharpe. From Zwartkop. p. 200.
15. Internal cast, magnified 8 diameters.
16. Exterior, magnified 8 diameters.
Figs. 17 & 18. *Turbo Bainii*, Sharpe. From Zwartkop. p. 200.
17. Internal cast (with portion of the shell remaining), magnified 6 diameters.
18. Exterior, magnified 6 diameters.

Fig. 19. *Acteon Atherstoni*, Sharpe; magnified 3 diameters. From Zwartkop. p. 200.
Fig. 20. *Ampullaria* ?, undetermined; magnified 12 diameters. From Zwartkop.
Fig. 21. *Ampullaria* ?, undetermined; magnified 10 diameters. From Zwartkop.
Fig. 22. *Natica Atherstoni*, Sharpe; natural size. From Zwartkop. p. 200.
Fig. 23. *Natica*, undetermined; magnified 15 diameters. From Zwartkop.
Fig. 24. *Cylindrites* ?, undetermined; magnified 12 diameters. From Zwartkop.
Fig. 25. *Acteon* ?, undetermined; magnified 8 diameters. From Zwartkop.
Figs. 26, 27, 31, 33, 34, 37, 38. Scales of *Palæoniscus Bainii*, Egerton: magnified 2 diameters. From Styl Kranz. p. 226.
Figs. 28, 29, 30, 32, 35, 36, 39, 40. Scales of *Palæoniscus sculptus*, Egerton; magnified 2 diameters. From Styl Kranz. p. 226.
Figs. 41 & 42. Fulcral scales from the base of the tail of *Palæoniscus*; magnified 2 diameters. From Styl Kranz. p. 226.

VII.—*Report on the Reptilian Fossils of South Africa.*

Part II.—*Description of the Skull of a large species of* Dicynodon (D. tigriceps, *Ow.*), *transmitted from South Africa by A. G. Bain, Esq.*

By Professor OWEN, F.R.S., F.G.S.

[Read May 16th, 1855.]

Plates XXIX. to XXXII.

Of the extinct *Reptilia* hitherto discovered in different regions of the globe, the fossil skulls of some species have exhibited combinations of characters now peculiar to distinct orders of the class, or even to distinct classes of Vertebrate animals. The *Ichthyosaurus*, for example, shows the piscine proportions of the premaxillaries in the upper jaw: the *Rynchosaurus* shows the chelonian absence of teeth in both jaws: but the *Dicynodon* seems to have borrowed its peculiarities from a higher class, and to have engrafted some mammalian characteristics upon the upper jaw, whilst it combined a chelonian edentulous under jaw, and a crocodilian occiput, with a cranium essentially constructed after the lacertian type.

These and most of the minor peculiarities of the cranial organization of the Dicynodont reptiles have been pointed out in my former account of some of the smaller species of the genus*. There were, however, in Mr. Bain's first collection some fragments indicative of a *Dicynodon*, with subcompressed tusks (*D. Bainii*), as large as a Walrus, but these were too scanty to deserve more than a reference to their indication of the size to which some species of that peculiar genus of reptile had attained during the mesozoic period in South Africa.

In a subsequent transmission of fossils from the Graaf Reinet district and Kafraria by Mr. Bain, two almost entire skulls of a still larger species of *Dicynodon* with circular tusks were included. They have been ably relieved from their extremely hard matrix by Mr. Dew at the British Museum, and they exhibit, with the long descending upper canines of the genus, a proportion and shape of the temporal fossæ more like those in the larger mammalian *Carnivora*, than in any known reptile, or than was indicated in any of the previously described smaller species of *Dicynodon*. Thus, of all the modifications of cranial structure which the fossil remains of extinct reptiles have offered to the contemplation of the naturalist, none have exhibited combinations of characters more extraordinary and suggestive than those presented by the old extinct Bidental Lizards of South Africa.

* *Vide supra*, p. 59.

In the species about to be described, which I propose to call *Dicynodon tigriceps* or the Tiger-headed Dicynodon, the general resemblance of the great mammalian *Carnivora* in the features which most impress the destructive physiognomy upon the skull is sufficiently striking.

The chief difference, irrespective of size, which the *Dicynodon tigriceps* presents, as compared with the *Dicynodon lacerticeps*, is the great expanse of the temporal fossæ (Pl. XXIX. 7, 12, 27, 28), and the great extent of osseous surface for the origins of the temporal muscles, which must have much exceeded the relative size of those muscles in any known existing reptile, and have equalled those of the tiger, lion, and other carnivorous mammals with large canine teeth.

Like the smaller species of *Dicynodon*, the *D. tigriceps* resembled the *Iguanæ*, *Varani*, and many other existing Lizards, in having but one zygomatic arch (Pls. XXIX., XXX. 26, 27, 28), the superadded one, formed by the extension of the post-frontal to the mastoid in the *Rynchocephalus**, and in the Crocodiles, not being developed. The normal zygoma formed by the malar (26) and squamosal (27), and by the junction of the latter with the mastoid (8) and tympanic (28), presents in the *D. tigriceps*, however, a form and expanse quite unique in the class of Reptiles.

The malar portion (26) quits the lower and hinder angle of the orbit (*o*), and, as it extends, changes its vertical for an horizontal plane, being, as it were, twisted upon itself so as to turn the upper border outwards: it then coalesces with the squamosal (27), and the arch is continued backwards, as a broad horizontally disposed plate of bone, slightly convex upwards, to the upper end of the tympanic (28), and the mastoid (8).

The mastoid (Pl. XXXI. 8) is continued from the back part of the zygoma (27), bending at almost a right angle as it ascends and passes forwards before contracting to join the extremity of the forked parietal (7). Below the mastoid the outer part of the occipital plate (4, paroccipital?) adds to the bony wall of the temporal fossa, and forms a broad, slightly convex prominence at the back part of that fossa. The inner side of the fossa, which forms a very small portion of the whole, encroaches upon the side of the body of the parietal (7), and is bounded above by a curved ridge of bone (Pl. XXIX.); the interspace of these parietal ridges is two inches at its narrowest part, which is just behind the median prominence supporting the foramen parietale (7). The temporal fossa communicates freely with the orbit (*o*).

The breadth of the skull across the broadest part of the zygomata is 18 inches, the length of the skull not exceeding 20 inches; for the extent of the upper jaw (Pl. XXX. 22) in advance of the nostrils may be pretty accurately estimated by the curvature of the portion which is preserved. The extreme breadth of the occipital

* See Pl. vi. figs. 5 & 7.

surface is 13 inches; the height of the same surface from the end of the basi-occipital processes is 8 inches.

The occipital condyle (Pl. XXXI. 1), which was broken away in the previously described specimens*, is entire in one of the large skulls, and in a fragment of another now under description: it is single, convex, subpedunculate, projecting freely from the foramen magnum with a broad reniform contour, being slightly excavated above: it seems to be formed wholly by the basioccipital, and appears small in proportion to the entire skull, the attachment of which to the trunk must have been powerfully secured by the mass of muscles inserted into the spacious and well-ossified occipital region (*ibid.* 3, 8, 4). The transverse diameter of the condyle is 1 inch 10 lines, its vertical diameter 1 inch 4 lines: on each side of the upper part of its base is the foramen condyloideum: the foramen magnum is a vertical ellipse, 1 inch 8 lines in its long diameter, and 10 lines across.

The basioccipital sends downwards a pair of hypapophyses (*hy*), which slightly diverge as they descend: they are subcylindrical, straight, truncated, 1 inch 9 lines in length, 1 inch in breadth, and deeply excavated externally, as in the *Iguanæ* and some other Lizards. From the outside of the base of this process the (par- ?) occipital extends outwards, downwards, and backwards, terminating in a low and large obtuse process (4), projecting backward, close to where this part of the occipital seems to unite with the tympanic.

The ex- and super-occipitals form a large triangular expanse of bone (3), vertical in position, but undulated and concave laterally above the foramen magnum, where it inclines a little forwards as it ascends: this expanse is overarched by the parieto-mastoid ridges (7, 8) on each side, where the surface is slightly convex at its upper half, concave below.

The major part of this peculiarly expanded occipital bony surface is formed of a comparatively thin subvertical plate of bone, formed by the branch of the parietal, the mastoid, and contiguous parts of the occipital: which plate afforded attachment at its posterior surface for the nuchal muscles, at its anterior one for the temporal muscles.

The cranium proper has the usual reptilian contracted calibre, and it seems the more contracted in the present great *Dicynodon* by comparison with the extent of the occiput and the still wider expanse and span of the zygomatic arches on each side. The upper surface of the cranium (Pl. XXIX.) is almost flat; it is horizontal, and is bent forwards at nearly a right angle with the occipital surface. It is bounded on each side by the temporal ridges, which turn the convexity of their curve towards each other: there is an eminence perforated by the foramen parietale (7)† in the

* See Pls. III.–VI.

† The foramen parietale has its margin raised in old and large Iguanas.

midspace; the surface is narrowest behind this foramen, where it is slightly concave and measures but 2 inches 3 lines across: in front of the foramen the cranial roof gradually expands with a flatter surface to the post-frontals (12).

On each side of the parietal part of the skull the temporal ridges (12, 7) bound a smooth elongated longitudinal concavity for the upper origin of the temporal muscles.

The frontal region continues increasing in breadth as it advances, and sends outwards an angular, rather rough, obtuse, antorbital process (14), probably formed by the prefrontal. Anterior to this the broad flat platform of bone begins gradually to bend downwards between the nostrils, Pl. XXX., *n*; but still expands and overarches those cavities by a strong tuberosity. Here the breadth of the facial part of the skull is at least 8 inches.

Judging by the curvature of the upper jaw anterior to the nostrils, and by the portion of the trenchant alveolar border which remains in front of the alveolus of the tusk (21), the anterior contour of the skull must have been such as is indicated by the dotted line at 22, Pl. XXX. In this side-view the total length of the skull from the back part of the mastoid root of the zygoma (8) to the end of the jaw so indicated gives 20 inches: the posterior border of the orbit (12, 25) divides this extent into two equal parts, the orbit being in the anterior half, and the posterior half being occupied chiefly by the temporal fossæ.

The posterior boundary of the orbit arches, from above, outwards, downwards, and backwards, of nearly the same breadth, which is 1 inch 3 lines; it is composed of the post-frontal (12) and malar (26) bones; the former descending to the lower border of the orbit, and the latter ascending behind the post-frontal, and gradually terminating in a point about an inch and a half from the upper surface of the cranium: the two bones are thus joined together by a long oblique suture. The malar appears to be continued backwards about three inches, along the inner side of the zygomatic platform, which is formed chiefly by the squamosal. In a second specimen of the skull of the *Dicynodon tigriceps* the post-orbital boundary descends more vertically, and the orbit is smaller.

In the more perfect example of the skull, Pl. XXIX., the orbit on both sides presents a subelongate triangular contour, with the angles rounded off, and the long diameter horizontal: this diameter is 4 inches; the vertical diameter at the fore part of the orbit is two inches and a half, whence it contracts to the posterior angle. The lacrymal foramen is situated just within the verge of the cavity, at the anterior inferior angle: about an inch above it, projects the antorbital process, divided by a notch and fossa from the supernarial tuberosity. The malar forms the chief part of the lower border of the orbit: it seems to extend to the lacrymal bone, and it rests in that extent upon the maxillary, Pl. XXX. (21), which is

continued backwards almost to the squamosal. The lower boundary of the orbit, so formed, increases in breadth and thickness as it advances, and assumes a trihedral figure.

The maxillary bends down from beneath the anterior half of the orbit, and swells out to form the tusk-socket (21 *c*), which is continued about an inch below the trenchant alveolar border. There is no extension of that border behind the tusk (*c*); that great descending tooth terminates the border of the mouth behind. The diameter of the tusk where it emerges from the socket is 13 lines: it is here broken off on both sides, in the specimen described; its transverse section is circular, not subelliptical, as in *D. Bainii*.

The nostrils, Pls. XXIX., XXX., *n*, are $3\frac{1}{2}$ inches apart at their anterior borders; they are oval, with the long diameter parallel with that of the orbit; the upper contour is more straight through the overarching tuberosity, the lower border is more curved: there is a trace of a suture descending from the middle of this border which unites the maxillary and premaxillary.

The premaxillary forms the anterior border, and where it descends, between the nostrils, its middle part is slightly raised. The fractured anterior end of the premaxillary shows the two parallel longitudinal ridges, or the fore part of the long palate, Pl. XXXII. 22.

The contour of the base of the skull, Pl. XXXII., forms an almost equilateral triangle with the hinder angles truncate. The posterior or palatal nostril (*p n*) is in the middle of the triangle; it is a simple narrow elliptical aperture 3 inches 9 lines long, and 1 inch 9 lines broad. It is bounded behind by the protuberant basisphenoid (5), which forms the narrowest part of the proper 'basis cranii.' From this protuberance four bony columns diverge, like a St. Andrew's cross; two (24) are slender, subcompressed, and diverge backwards to abut against the lower end of the tympanic pedicle; two (20) are thicker, but also subcompressed and rounded below; they diverge forwards, to form the sides of the posterior nostril; these increase in thickness as they advance and unite with other bones,—the palatines,—which converge to bound the posterior nostril in front; a strong buttress of the maxillary diverges from the above united bones to strengthen the inner side of the tusk-socket (21). There seems to have been an oblong tuberosity at the middle of each lateral border of the posterior nostril; part at least of such a projection has there been broken off. The bony palate in advance of the posterior nostril is entire; it is concave, most so from side to side, but shows three thick, obtuse, longitudinal eminences; one at its hinder half, in the middle line (13); the other two at the fore part (22) on each side of the middle line: these latter divide the fore part of the palate into three longitudinal chambers. The length of the bony palate is 7 inches, its breadth $4\frac{1}{2}$ inches.

The trenchant edentulous border rises as it advances from the tusk-socket, and then slightly descends to the fore part of the beak-like termination of the upper jaw.

Lower jaw.—Of this there is the anterior portion, including the symphysis, where the rami are extensively confluent; such portion being conformable in size with the above-described cranium of the *Dicynodon tigriceps*. The symphysis (Pl. XXX. 32) is deep, curved lengthwise, with the convexity forwards, and more convex transversely; it appears to have been traversed by a median low obtuse ridge externally, corresponding to the median ridge of the premaxillary: its extent following the curve is not less than seven inches; its breadth, following the curve, three and a half inches. An extent of seven inches of the alveolar border of the left ramus is preserved; this border shows a slightly convex, prominent, vertical, longitudinal ridge on its inner side, a straight and lower ridge on its outer side, and an intervening groove, which, beginning five inches from the fore part of the jaw, gradually acquires a depth of six lines at the fractured end of the ramus. Not the slightest trace of teeth is visible. A strong longitudinal obtuse angular bar of bone (*x*) begins to project from the outside of the ramus, four inches from the anterior end of the jaw, and one inch below the alveolar border. The dentary element shows a notch (*v*) below the back part of the bar indicative of a small vacuity in this part of the jaw. The fractured surfaces of the rami expose the vertical fissure or division of the dentary element for junction with the hinder elements of the compound bone.

In the shape and extent of the symphysis, and in the exterior bar or ridge, the lower jaw of the present large species repeats the generic modifications, previously described, of that of the smaller species of *Dicynodon*.

Comparison of the Dicynodon tigriceps *with the* D. lacerticeps.

The most complete of the smaller skulls described in the first part of this Report* had been mutilated to the same extent by the breaking off of the upper jaw anterior to the nostrils, as is the best preserved of the larger skulls here described; but being similarly perfect in other respects, it affords the subject of an instructive comparison.

On a side view, the *Dicynodon tigriceps* differs from the *D. lacerticeps* in the relatively larger size of the temporal fossa and in the smaller size of the orbit: the great expanse of the temporal fossa involves also a different relative position of the orbit, which in *D. lacerticeps* occupies the middle third of the skull; whilst in *D. tigriceps* it is in the anterior half: the orbit is also of a different form, being almost circular in *D. lacerticeps*, and equalling the temporal fossa in size. The nostrils also appear to be relatively larger in *D. lacerticeps*, but this difference may be

* See above, p. 62, and Pl. III.

exaggerated by the less entire state of their bony circumference in the specimen of the first-described and smaller reptile.

In a comparison of the occipital region, the mastoideo-parietal ridges appear in *D. tigriceps* to subside sooner as they ascend, converging to the top of that region; and, though these ridges are less entire in the larger than in the smaller skull compared, the difference does not seem to be wholly due to accidental mutilation: the part above the foramen magnum seems to be naturally more concave from side to side than it is in *D. tigriceps*, in which the above ridges meet at top and there overhang the superoccipital region. In *D. lacerticeps*, the par- and ex-occipital plates abut against the mastoids and tympanics by three short thick truncate processes on each side: in *D. tigriceps* the union of the same parts seems to have been continuous and unbroken. The hypapophyses are relatively shorter and thicker in *D. lacerticeps*. The whole occipital region is broader in proportion to its height in *D. tigriceps*.

In a comparison of the upper surface, the cranium proper is shorter in proportion to its breadth, and the foramen parietale is relatively nearer the back part in *D. tigriceps*; and the flat space between the temporal ridges is relatively much greater. In *D. lacerticeps* (see Pl. III. fig. 2), these ridges nearly meet behind the foramen parietale. This is an important difference, as bearing on the question of the relation of the smaller to the larger skull, in regard to individual age. A young carnivorous animal differs from an old one of the same species in the smaller extent to which the origins of the temporal muscles ascend on the sides of the cranium; the interspace above, between those ridges, being broader as the animal is younger; whilst in the full-grown, especially the males, it becomes obliterated, and a further extent of origin is afforded to the biting muscles by the development of a median parietal crest.

The extent of origin of the temporal muscles from the sides of the parietal bone, in *D. lacerticeps*, indicates the small skull, exhibiting that extent, to have been of a full-grown, if not old individual; the smaller relative extent of the same muscular attachments, and the wider flat interspace between those origins, in *D. tigriceps*, as shown in the two large equal-sized skulls, which seem to have come from adult individuals, plainly indicate, with the different form and proportions of the cranium, and the other differences above pointed out, a specific distinction from the *D. lacerticeps*.

The profile of the skull in *D. lacerticeps* begins to slope or curve down from a line parallel with the back part of the orbits; but in the great *D. tigriceps* it does not begin to bend down until in advance of the orbits; and the preorbital part of the skull, with the interorbital space and the interspace of the nostrils, is relatively broader in *D. tigriceps* than in *D. lacerticeps*.

DESCRIPTION OF THE PLATES.

Plate XXIX.

Oblique view of the skull of the *Dicynodon tigriceps*, natural size.
(From Gonzia River, Kafraria.)

Plate XXX.

Side view of the same skull: half natural size.
(The fragment of Lower Jaw figured on this Plate is from Bovey's Farm.)

Plate XXXI.

Back view of the same skull: half natural size.

Plate XXXII.

Base view of the same skull: half natural size.

The same figures and letters indicate the same bones or parts in each Plate.

1. Occipital condyle (basioccipital).
3. Superoccipital.
4. Paroccipital.
5. Basisphenoid.
7. Parietal.
7′. Parietal foramen.
8. Mastoid.
12. Postfrontal.
13. Median ridge of bony palate, probably the vomer.
14. Prefrontal.
20. Palatal.
21. Maxillary.
22. Premaxillary.
24. Pterygoid.
26. Malar.
27. Squamosal.
28. Tympanic.
32. Mandibular symphysis.

c. Canine tusk. *o*. Orbit. *n*. External nostril. *pn*. Internal nostril. *x*. Dentary ridge.
v. Dentary notch. *hy*. Occipital hypapophysis.

VIII.—*Report on the Reptilian Fossils of South Africa.*

Part III.—*On parts of the Skeleton of the Trunk of the* Dicynodon tigriceps.

By Professor OWEN, F.R.S., F.G.S.

[Read June 13th, 1855.]

Plates XXXIII. and XXXIV.

MANY of the nodules of the hard rock which forms the matrix of the skull of the *Dicynodon tigriceps* contained bones which belonged to other parts of the skeleton: some of these have been more or less relieved from their bed, and the following are amongst the best-preserved and most intelligible specimens at present exposed.

Vertebræ.—In the first part of the present Report on the Reptilian Fossils of South Africa, I briefly noticed the biconcave structure of the vertebræ of the *Dicynodon*, as indicating "a more aquatic and perhaps marine theatre of life" for these ancient African Saurians, than any existing species of that order are now known to manifest in that continent. (*Vide supra*, p. 83.)

A vertebra (Pl. XXXIII. figs. 1–3), from the anterior part of the dorsal region, seems to belong, from the proportion which its articular surface bears to the condyle of the occiput of the *Dicynodon tigriceps*, to the same species, or at all events, to an individual of the same size. As it was imbedded in the same block with a skull and other bones of the *Dicynodon tigriceps*, it is most probably of the same species.

The centrum and neural arch are partially anchylosed, with definite traces of the suture, which is in the usual position (*n*). The centrum is short; the contour of the articular surface is subcircular; the margin is convex for about three lines, and then the surface sinks into a deep conical concavity, the apex of which nearly meets that of the concavity of the opposite articular surface (fig. 3). The non-articular surface is smooth, moderately concave lengthwise, impressed at the upper and anterior angle of the centrum with the lower half of a vertically oval concave surface (*p*), for the articulation of the head of a rib.

The base of the neurapophysis (*n*) is coextensive with the centrum; as it rises, it is slightly emarginate before and behind for the outlet of the nerves, and is extended outwards in the form of an oblique ridge. The neural canal is subcircular; above its anterior outlet are the bases of a pair of zygapophyses (*z*). The strong oblique ridge which rises from the outer and fore part of the base of the neurapophysis extends backwards, as it rises, to support the diapophysis (*d*); the base of this process is of great strength, and extends outwards and rather

upwards and backwards from the side of the summit of the neural arch; its free portion or extremity is broken off. The spinous process (*ns*) inclines a little backwards, and is compressed with a sharp anterior border.

The following are the dimensions of this vertebra:—

	In.	Lines.
Length of centrum	1	5
Breadth of centrum	2	0
Height of centrum	1	10
Length of spinous process	2	0
Antero-posterior diameter of spinous process	0	10
Total vertical diameter or height of the vertebra	5	0
Transverse diameter of neural canal	0	7

This remarkable vertebra combines peculiarities borrowed, as it were, from different genera of Saurians. In the proportions of the centrum, neural arch, and spine, it resembles the vertebræ of the *Plesiosaurus*; in the deep concavity of each articular end, it resembles the vertebræ of the *Ichthyosaurus*, the Perennibranchiate Batrachians, and Fishes. The indications of the twofold articulation of the thoracic rib, viz. by a head to the centrum and by a tubercle to the transverse process, mark an affinity to the Crocodiles and Dinosaurs, and make it probable that the *Dicynodon* possessed the higher structure of the heart which characterizes the *Crocodilia* among existing reptiles.

Sacrum.—Of this characteristic part of the vertebral column there are two exemplifications (Pl. XXXIII. figs. 5 & 6), which are respectively either the entire sacrum of two distinct species, or are parts of the same sacrum, or of the sacrum of the same species. Each specimen consists of two vertebræ, anchylosed, and with the usual unmistakeable sacral modifications of the articular surfaces of the centrums and developments of the pleural elements. But these elements are so differently modified in each, as clearly to determine a difference of one or the other of the two kinds above mentioned. I shall first describe the sacrum, or portion of sacrum, figured in Pl. XXXIII. figs. 4 & 5, next that represented in figs. 6 & 7, and finally give the grounds, from the comparison of the two, which incline me to the conclusion that they are parts of the same sacrum according to the type of the *Dinosauria*, rather than two different sacrums with the restricted number of vertebræ characteristic of the recent and fossil Crocodilian and Lacertian reptiles.

The specimen (Pl. XXXIII. figs. 4 & 5) includes two vertebræ, the bodies of which measure together five inches in length, and are three inches across the expanded articular ends, which are nearly flat. The lower half of the anterior of these vertebræ (fig. 5) has been broken away; what remains of the anterior expanded end is slightly concave. The head of the sacral rib (*pl*) is of very great

breadth; it has articulated with and become anchylosed to a thick and strong parapophysis from the side of the centrum, extending to within a short distance of its hinder end; it next becomes confluent with a broad and thick neural platform, which expands laterally into the broad depressed diapophysis (*d*), to the ends of which are traces, in the form of raised borders, of the articulation and actual anchylosis of the tubercular part of the sacral rib. This rib then augments in breadth, diminishes in depth, and forms a depressed but strong and broad plate of bone, which is bent backwards at a right angle for the extent of seven inches, increasing again in vertical thickness after the bend, where it receives the abutment of the second sacral rib on the inner side, and on the outer side presents a rough concave surface for the iliac bone. The breadth of the neural platform where it forms the hinder zygapophyses is four inches; the articular surface of those processes looks downwards; the spine of the first sacral vertebra is broken; that of the second is short, thick, expanded and truncate at the summit (fig. 4, *s*).

The sacral rib of the second vertebra has a similar attachment, by its head, to the upper half of the side of the centrum, and, by the part answering to the tubercle which coalesces with the broad superincumbent neural platform, and extends outwards, expanding, chiefly in the backward direction, so as to abut upon and overlap the rib of the foregoing vertebra, and form the upper expanded part of the sacro-iliac surface.

The length of the middle part of this sacrum or portion of sacrum is between 5 and 6 inches; the breadth is 13 inches. The body of the second sacral vertebra is subcompressed at its middle part, smooth and broadly rounded below. It terminates behind in a flat, rough, evidently fractured surface, indicative of its having been violently separated from a third anchylosed sacral vertebra.

The second sacrum or portion of sacrum (figs. 6 & 7) includes also two anchylosed vertebræ, the bodies of which present almost the same size and form as those of the preceding specimen: their coadapted ends are completely confluent: the opposite ends are broken; but on one of these is part of a smooth surface, which indicates it to have formed one end, probably the hinder end, of the sacrum. In each vertebra the sacral rib springs from the confluence of the centrum and neural arch, gradually contracts as it extends outwards, where it presents a full elliptical transverse section; then again expands, meeting the similarly modified succeeding rib, with which it coalesces to form a sub-bilobed, flat, rough surface (*pl*) for abutment against part of a pelvic arch. In each of these sacral vertebræ the neural spine (fig. 7) expands as it ascends, and terminates in the same broad truncate surface as that of the spine of the preceding sacral specimen (fig. 4, *s*). It is quite certain that neither of the rib-elements of the second (portion of?) sacrum can have been modified like the singularly expanded ribs of the first: they have been

wrought out clearly and without fracture to the more slightly and normally expanded ends above described and shown in fig. 6.

The second of the vertebræ in fig. 5 shows by the termination of its centrum that it was not the last sacral vertebra; whence it is to be inferred that the number of those in the *Dicynodon* exceeded two; whilst the close correspondence between the bodies, and especially between the peculiarly shaped neural spines of the two sets of sacral vertebræ (figs. 5 & 6), leads me to the conclusion that they are anterior and posterior parts of the same sacrum, or of the sacrum of the same species. They were, however, wrought out of different fragments of the matrix, and cannot be made to fit; so that there may be more than four vertebræ in the sacrum of the *Dicynodon*.

In the series of bones appertaining, to judge by their size and associated locality, to the *Dicynodon tigriceps*, are two belonging to the arches that have supported the fore and hind limbs.

One of these (Pl. XXXIV. fig. 2, *s*, *g*) is a single, broad, and flat bone, with part of the cavity for the head of the proximal long bone of the limb, showing at the lower half of its circumference an elongated rough surface, apparently for synchondrosis with the other elements of the arch contributing to complete that cavity: on one side of the more expanded part of the bone is an extensive rough surface (figs. 2&3, ×, ××) apparently for similar ligamentous junction with another part of the skeleton. The other bone (fig. 1) exhibits the entire cavity for the proximal bone of its limb, and is obviously composed of the vertebral (or pleural) and sternal (or hæmal) elements of the arch anchylosed where they constitute that articular cavity, traces of the obliterated suture being there discernible.

According to the analogy of the *Reptilia*, the longer and narrower of the two constituents of the last-cited arch should be the pleural one, the broader and shorter the hæmal element; and this latter likewise exhibits a foramen (*o*) near the articular cavity which may either be interpreted as an 'obturator foramen,' or an homologue of the foramen which is found in the coracoid of the Crocodiles, of the Monitors (*Varanus*), and of many other Reptiles, recent and fossil.

Pelvic arch.—The bone represented in figure 1, Pl. XXXIV., resembles in its general proportions the coracoid of the *Megalosaurus*. The anchylosed condition of the two parts of the arch where they form the articular cup in fig. 1. Pl. XXXIV. renders it most probable, however, that they belong to the pelvis, and I, provisionally, regard them as the left 'os innominatum' of the *Dicynodon*. The pleural element or 'ilium' (*a*, *b*, *c*) is an inequilateral triangular plate of bone, with the lower angle thickened and expanded, especially externally, to form the upper half of the acetabulum. Its anterior border (*a*, *b*) is the longest, nearly

straight, and moderately thick and rounded: the upper border, or 'crista,' soon becomes thin on quitting the angle *a*, and is continued backwards and downwards, with a slight degree of convexity, and at an acute angle with the anterior border. The hinder or lower border is short, concave, and rapidly thickens as it approaches the acetabular cavity. The outer surface of the ilium is slightly concave and smooth: the anterior or antero-lateral surface is narrow, and divided by a broad ridge of bone from the inner surface, which shows many longitudinal and slightly converging grooves near the thin margin, indicative of the junction with the expanded ribs of the first and second sacral vertebræ, which I suppose to have abutted against or overlapped this part of the ilium. The posterior angle of the ilium (*c*) appears to have projected backwards. The hæmal element of the pelvic arch, consisting seemingly of a confluent ischium (*t*) and pubis (*s*), forms a strong and thick subsemicircular plate of bone, moderately concave externally, convex at its upper part and upper inner part, slightly convex vertically and slightly concave transversely, in the rest of the inner surface, which formed part of the wall of the pelvic canal. Near the convexity, answering to what is termed the brim of the pelvis in *Mammalia*, is an elliptical foramen, $1\frac{1}{2}$ inch by 1 inch, in long and short diameters: it is the commencement of a canal, which perforates the bone obliquely downwards and forwards, opening externally below the thickened part of the pelvic brim, and about two inches from the acetabulum, at *o*. The brim of the pelvis becomes thinner as it approaches the symphysis pubis (*s*, *s*); and it has been more extended apparently outwards, but has been here fractured. The symphysial surface is semi-elliptic or reniform, $6\frac{1}{2}$ inches in length, 3 inches across at its broadest part, forming an acute angle with the outer surface, which it thus meets by a sharp border: the lower part of the ischio-pubic bone is continued at an obtuse angle from the symphysial border, is at first thin, and then becomes thickened to form the projecting, strong, roughened angle, answering to the ischial tuberosity (*t*). The space between this process and the posterior superior spine of the ilium (*c*) forms a part answering to the great ischiadic notch in *Mammalia*. Some traces of the original suture between the ilium and the ischio-pubic plate are discernible in the articular cavity.

The following are the dimensions of the above-described os innominatum:—

	In.	Lines.
Total length, following the outer curve	21	0
Length of the ilium	11	0
Breadth of ditto at its base or labrum	9	0
,, of the neck or narrow part	3	9
Transverse diameter of acetabulum	5	0
Length of ischio-pubis	8	0
Breadth of ischio-pubis	9	0

Scapular Arch.—The bone represented in fig. 2, *s*, *g*, & fig. 3, Pl. XXXIV., is either a scapula, or a 'coracoid.' Its glenoid or articular process (*g*) is subtriangular, $5\frac{1}{2}$ inches by $4\frac{1}{2}$ inches in the long and short diameters, divided at its extremity into a symphysial surface for articulation with the scapula, and into the portion of the glenoid articular cavity. The bone, as it extends from this twofold articular end, contracts, and chiefly in transverse diameter, to a subcompressed neck, thickest and rounded behind, 3 inches 9 lines in fore-and-aft diameter, 2 inches in thickness, 5 inches in vertical extent at the back part, and 2 inches in the same dimensions at the fore part. The bone above this constriction suddenly expands into a broad semioval strong plate; 12 inches in antero-posterior extent, 6 inches in vertical diameter, and about 2 inches thick at its thickest part (*s*). This plate extends about $2\frac{1}{2}$ inches in advance of the neck, and terminates anteriorly in a convex border (×); from this part it increases in vertical extent to the middle of the bone, and continues slightly diminishing to the hinder border (××), which is nearly vertical: the upper border is moderately convex, and the angle is rounded off by which it passes into the hinder border. The whole outer surface of the expanded plate of the bone is slightly concave.

The inner surface, fig. 3, is moderately convex, and a great proportion of it, including the whole fore-and-aft extent and 5 inches vertically, is occupied by a rough irregular, apparently synchondrosal surface. This structure, with the modifications of the ilium and sacral ribs before described, indicates the power of the *Dicynodon* to support and move itself upon dry land, like the Crocodiles, and to a degree probably equalling that of the Dinosaurs.

Supposing the above-described bone to be a 'scapula,' there is, then, a third bone, *c*, *p*, fig. 2, perforated like the ischio-pubic bone, but differing in shape. It may be a coracoid bone: it bears a certain resemblance to the coracoid of the *Iguanodon*.

Humerus or *Femur*.—Of the long bones of the extremities, the most intelligible is one which is remarkable for the slenderness of the shaft in comparison with the extreme expansion of its distal end; Pl. XXXIV. fig. 4. The shaft is trihedral, with the angles rounded off, 3 inches in its longest diameter about an inch above the beginning of the expansion of the distal end. The fractured surface, here, shows no trace of a medullary cavity. From one side of this part of the shaft a strong ridge is continued outwards and downwards, which expands as it descends; it resembles the supinator ridge of the humerus in carnivorous *Mammalia*. The condyle which swells out anterior to this ridge is convex and of large size. The outer part of the other and smaller condyle has been broken away; the under part of the condyles is gently concave from side to side: the back part of the expanded end is very slightly concave, so far as it is

preserved, but the whole border of the lower and back part of the expanded end of the bone is broken away. The breadth of the distal end of this bone, as mutilated, is 7 inches; its circumference nearly 18 inches; the circumference of the shaft being $7\frac{1}{2}$ inches.

DESCRIPTION OF THE PLATES.

Plate XXXIII.

Vertebræ and Sacrum of the *Dicynodon tigriceps*.

Fig. 1. Side view of a middle or anterior dorsal vertebra.
Fig. 2. Front view of the same.
Fig. 3. Section of the centrum, showing its bi-concavity.

n. Neurapophysis.
p. Parapophysis.
d. Diapophysis.
z. Zygapophysis.
ns. Neural spine.

Figs. 1–3 are of the natural size.

Fig. 4. Upper view of the first two sacral vertebræ.
Fig. 5. Under view of the same.
Fig. 6. Under view of two posterior sacral vertebræ.
Fig. 7. Back view of the same.

pl. Pleurapophysis or rib-element.

Figs. 4–7 are $\frac{1}{4}$th of the natural size*.

(Figs. 4–7 are from East Brak River, Fort Beaufort.)

Plate XXXIV.

Pelvic and Scapular arches and Limb-bone of the *Dicynodon tigriceps*, $\frac{1}{4}$th natural size.

Fig. 1. Left 'os innominatum': *a*, *b*, *c*, ilium; *s*, *s*, *t*, ischio-pubic bone; *o*, obturator foramen; *t*, tuber ischii; *t*, *c*, ischiadic notch.
Fig. 2. *s*, *g*. Scapula, or coracoid? (From near Tola's Kraal, Kafraria); *c*, *p*. Coracoid? (Road to Block Drift).
Fig. 3. Scapula, or coracoid? (Near Tola's Kraal, Kafraria.)
Fig. 4. Distal end of humerus or femur. (East Brak River, Fort Beaufort.)

* Since this part of the 'Report' was in type, an almost entire pelvis of the *Dicynodon* has been exposed in a block of matrix: it will be described hereafter.

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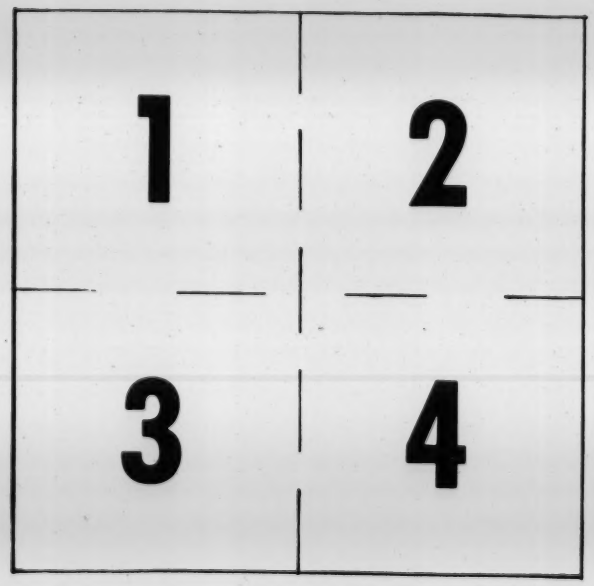
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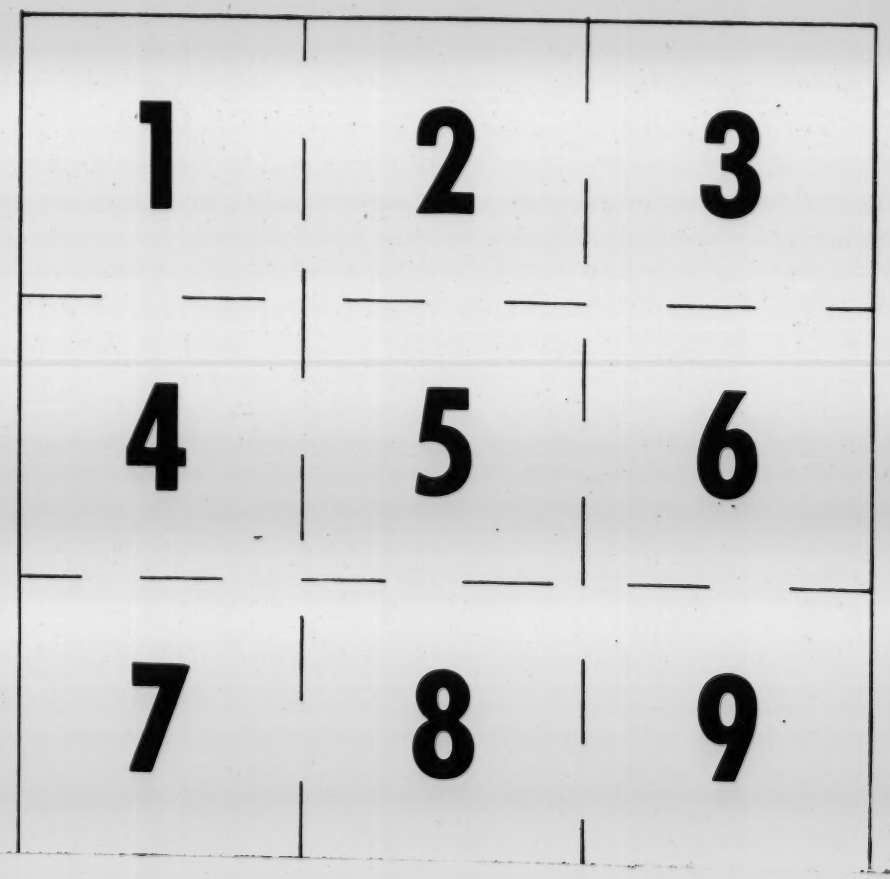
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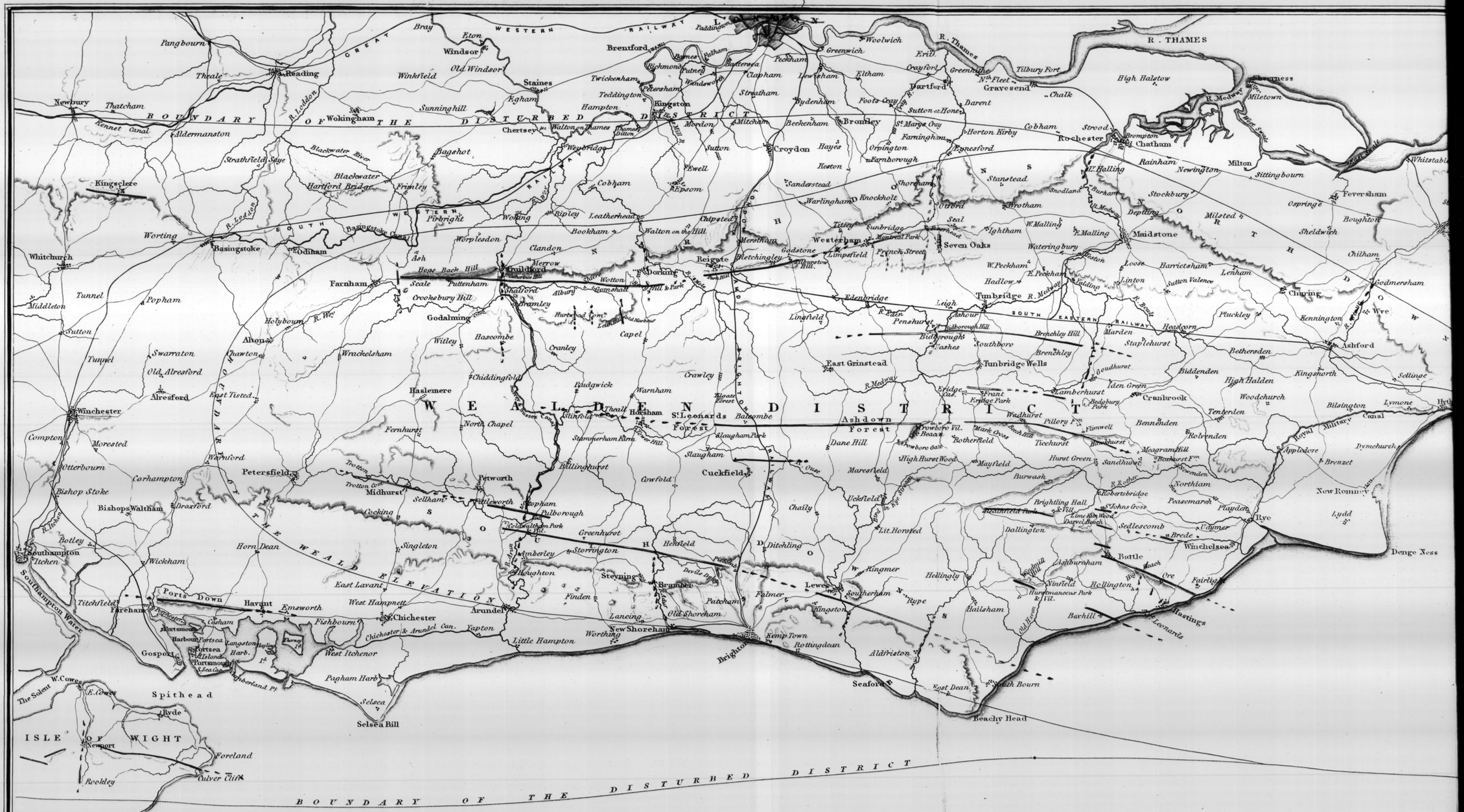
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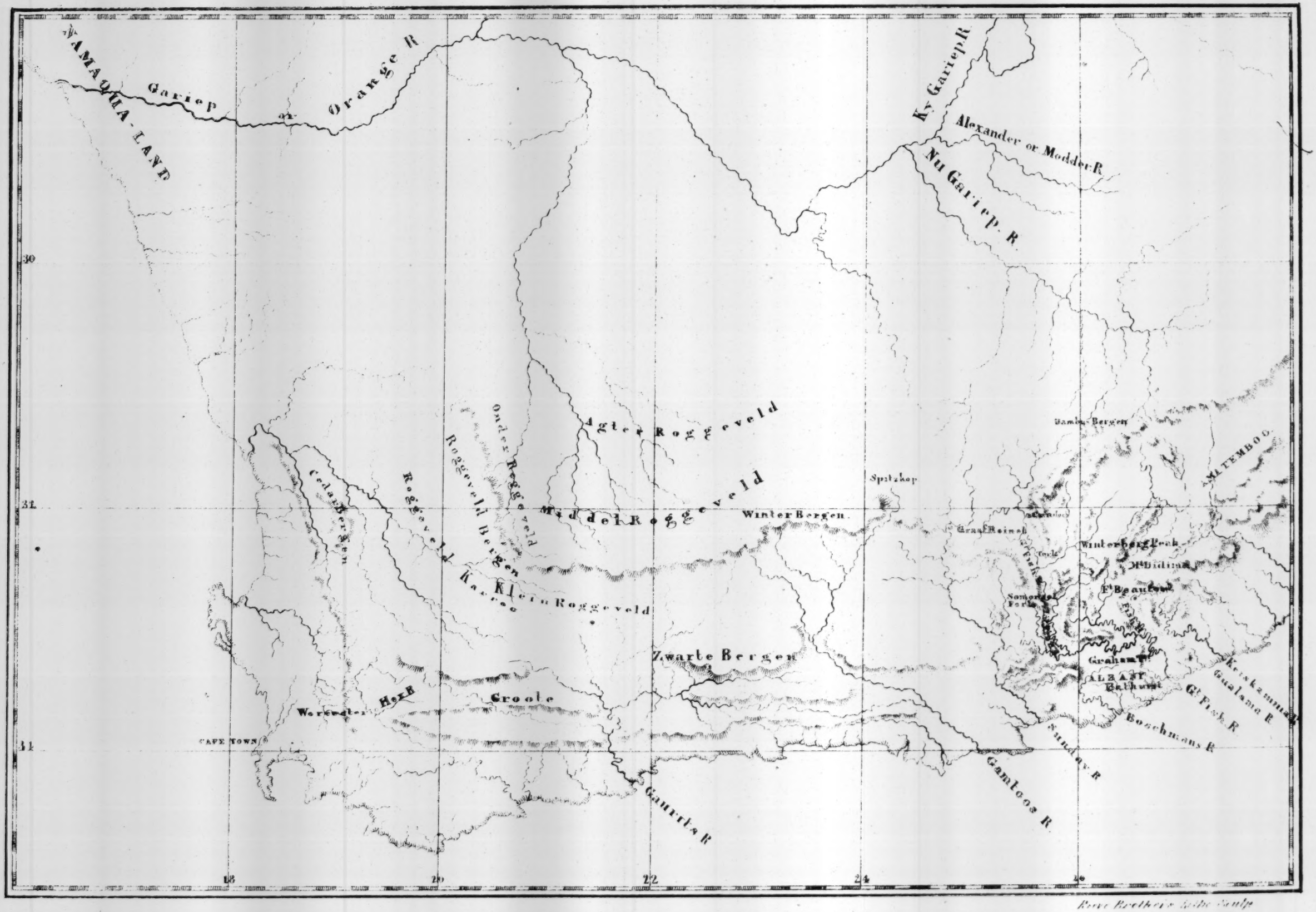






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Ospringe
Faversham
Sturry
Fordwich
Canterbury
THE SMALL DOWNS
Boughton
Sheldwich
Wingham
Sandwich
Wrotham
R. Medway
Deptford
Milsted
NORTH DOWNS
Otford
Seal
Ightham
W. Malling
E. Malling
Maidstone
Seven Oaks
Watteringbury
Chilham
Bridge
Eastry
Deal
THE DOWNS
Weston
Loose
Harrietsham
Lenham
W. Peckham
E. Peckham
Hadlow
Yalding
Linton
Sutton Valence
Godmersham
Womenswould
Tunbridge
R. Medway
Charing
Walmer
Leigh
R. Beult
Pluckley
Kennington
R. Stour
Wye
Denton
SOUTH EASTERN RAILWAY
Ashour
Headcorn
Lydden
Ewell
Tudborough Hill
Marden
Brenchley Hill
Staplehurst
Ashford
Southboro
Brenchley
Bethersden
Dover
Tunbridge Wells
Goudhurst
Biddenden
High Halden
Kingsnorth
Sellinge
Iden Green
Frant
Lamberhurst
Woodchurch
Cranbrook
Bilsington
Lymone
Hythe
Folkstone
Fridge Park
Bedgbury Park
Tenterden
Sandgate
Wadhurst
Pillory F.m
Flimwell
Bennenden
Royal Military Canal
Mark Cross
Beech Hill
Rolvenden
Rotherfield
Ticehurst
Hawkhurst
Meagram Hill
Dymchurch
Appledore
Brenzet
Mayfield
Hurst Green
Sandhurst
Burwash
R. Rother
Northiam
New Romney
Robertsbridge
Brightling Hall & Vill.
St. Johns Cross
Peasemarsh
Playden
Rye
Lydd
Lime Kiln Wood
Darvel Beach
Sedlescomb
Udimer
Dallington
Brede
Winchelsea
Denge Ness
Battle
Ashburnham
Windmill Hill
Big Beach
Ore
Fairlight
Vinefield
Hollington
Hurstmanceux Park & Vil.
Hailsham
Bexhill
St. Leonards
Hastings
Old River
South Bourn
Beachy Head
STRAIT OF DOVER
Calais
C. de Blanc
Marck
Peuplingue
Bonningue
Guines
Ardres
Wissant
C. Grisnez
Auxdresselles
Basinghen
Marquise
Amblefeuse
Slack
Licques
Maninghen
Wierre Effroy
Bouvin
Wimille
Wimereux
Nesdrel
BAS
Wimereux R.
Fte la Creche
Belle
Ottenburg
St. Omer
Boulogne
Col. de Nap.
Mt. Lambert
Alinetun
Henneveux
Brunembert Road
BOULONNAIS
Beinetun
Bournonville
Lainghen
Desvres
Condette
Samer



Rowe Brothers lith. Sculp.

MAP of a portion of Southern Africa

Fig: 1.



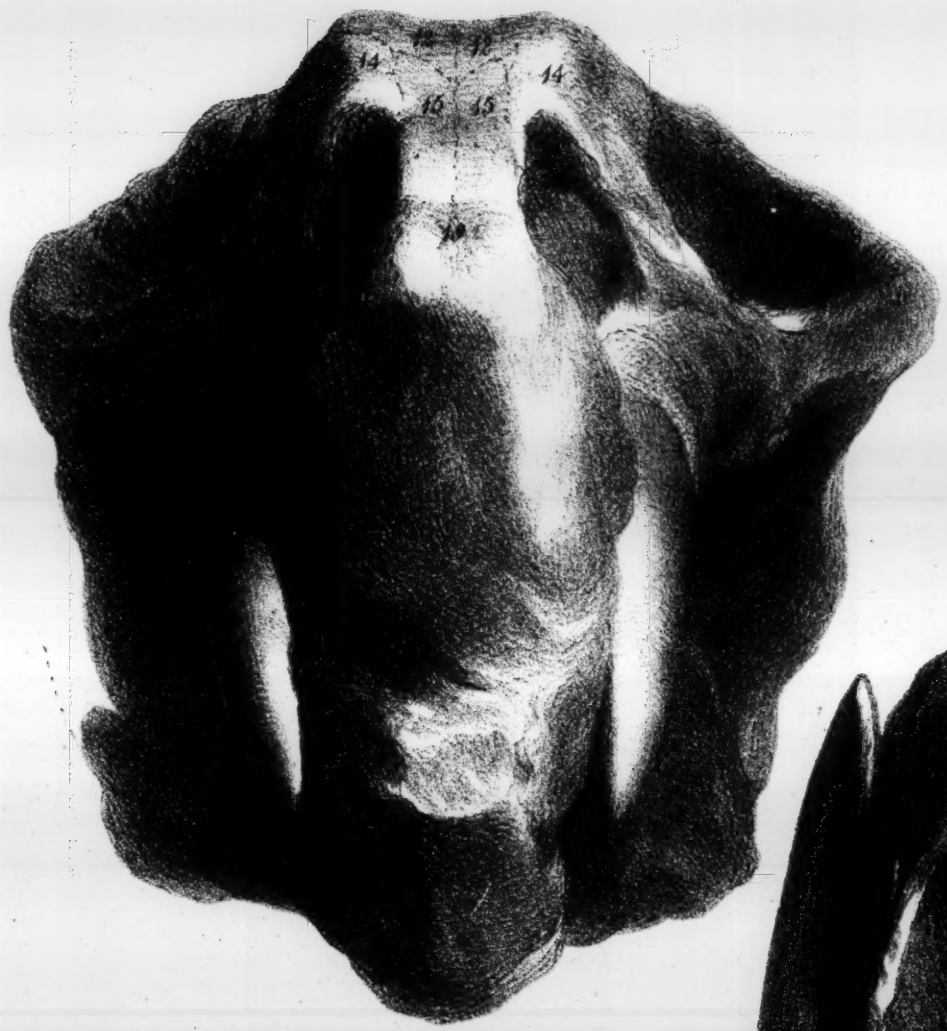
Fig: 2.

Drawn from Nature by G. Scharf.

Printed by Hullmandel & Walton.

Diagnodon lacericeps.

1



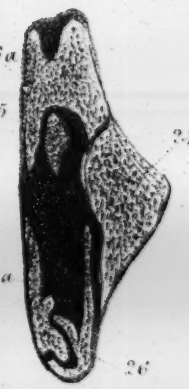
2





5

6



3



4

Lithog. from Nature by G. Scharf

Printed by Hullmandel & Walton

Dicynodon lacerticeps.



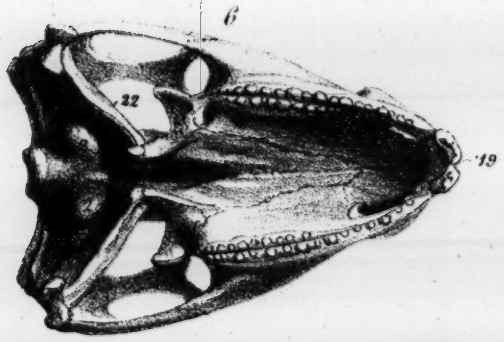
Lithog from Nature by G. Scharf.

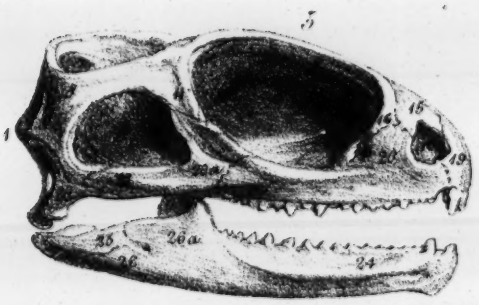
Printed by Hullmandel & Walton.

Dicynodon testudiceps.

—



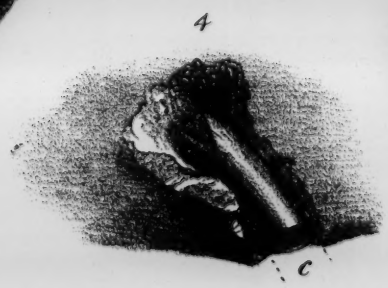








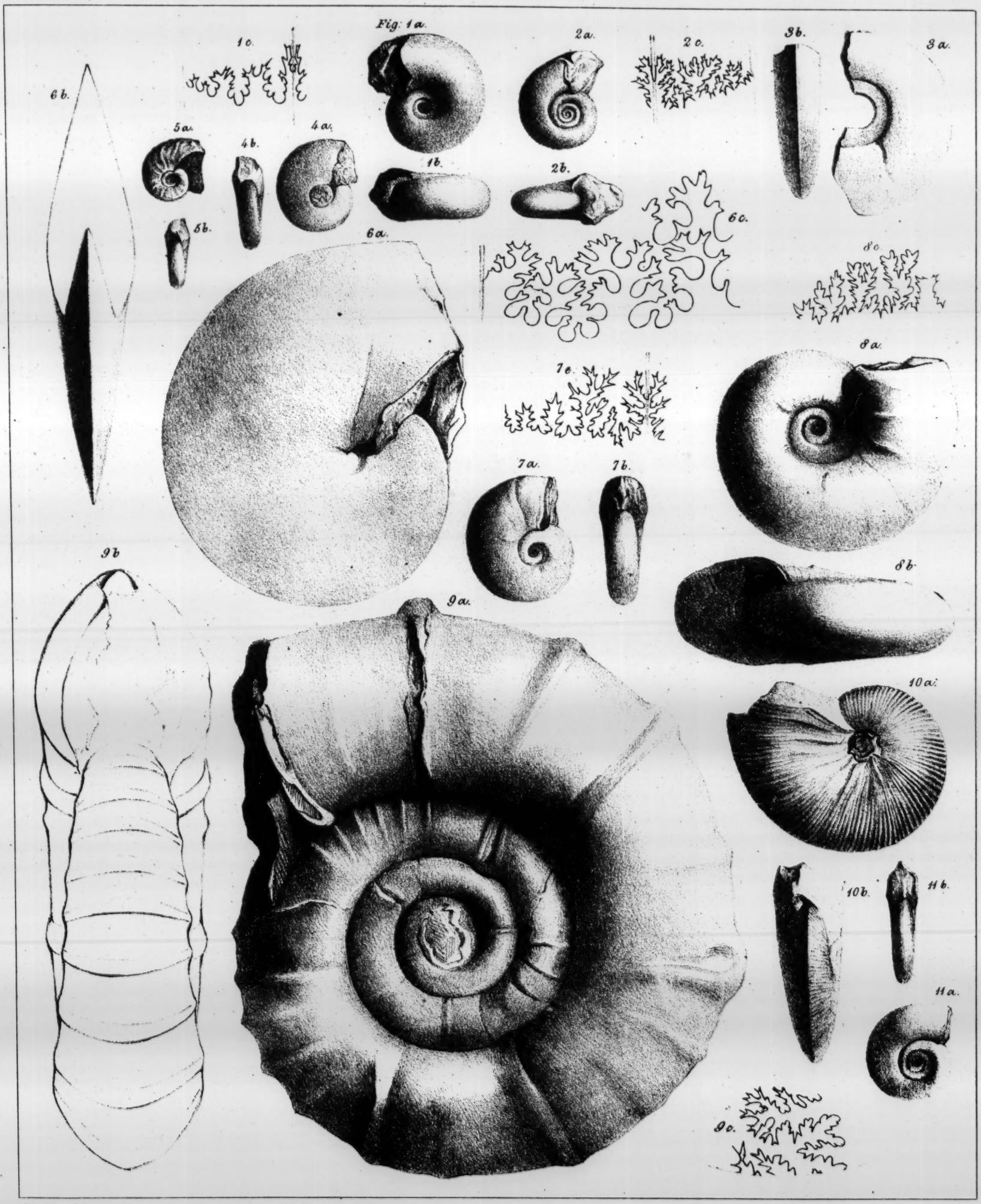




Printed by Hullmandel & Walton.

1. Dicynodon testudiceps. 2. 3. D. strigiceps. 4 & 6. Rhynchocephalus (recent)

Jun. 15 19[illegible]

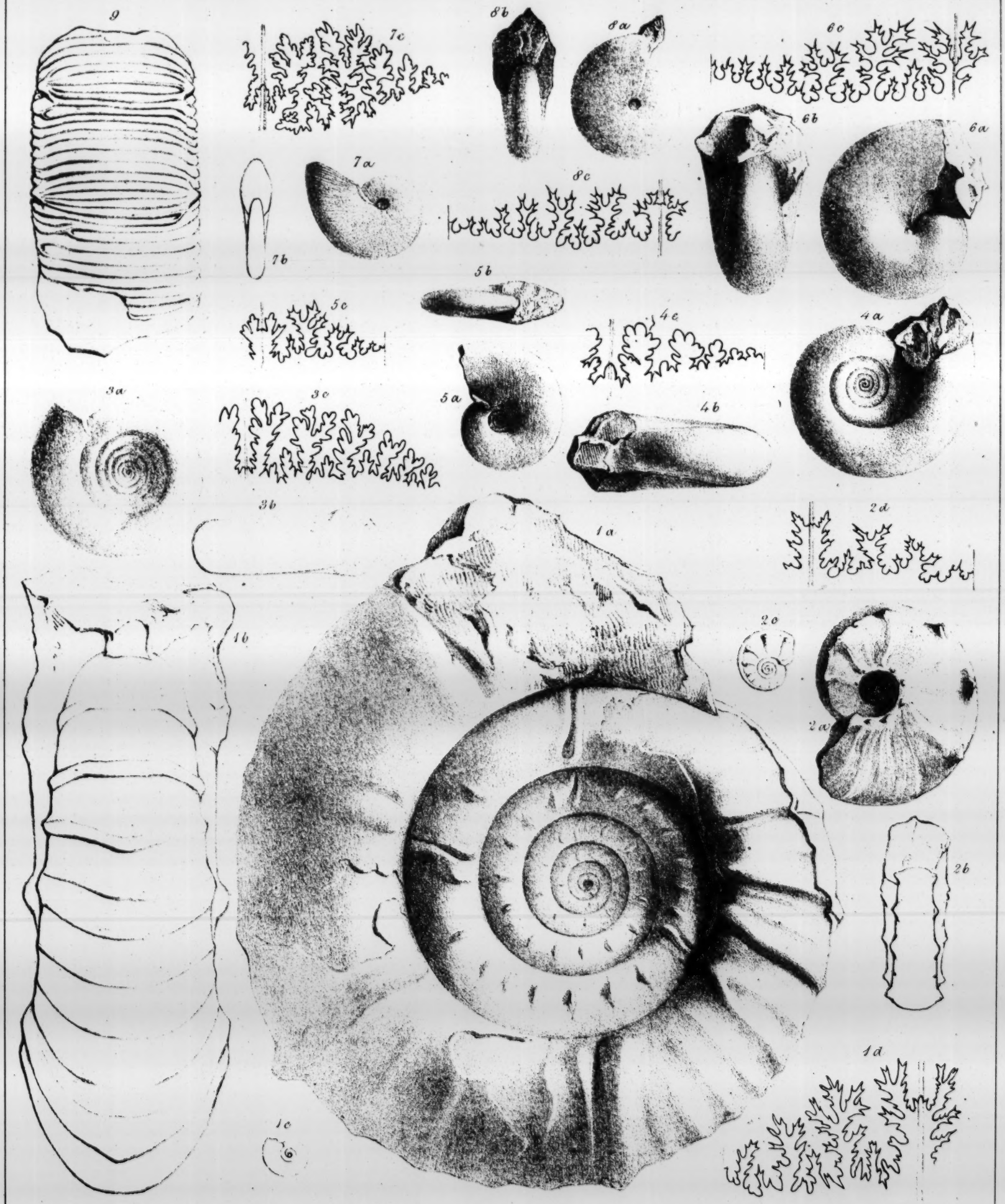


C.R. Bone lith.

Hullmandel & Walton lithographers.

Fig: 1. a. b. c.	Ammonites	Garuda. n.s.
2. a. b. c.	"	Juilleti. d'Orb.
3. a. b.	"	Rembha. n.s.
4. a. b.	"	Yama. n.s.
5. a. b.	"	Pavana. n.s.
6. a. b. c.	"	Siva. n.s.

Fig: 7. a. b. c.	Ammonites	Soma. n.s.
8. a. b. c.	"	Ganesa. n.s.
9. a. b. c.	"	Vishnu. n.s.
10. a. b.	"	Surya. n.s.
11. a. b.	"	Durga. n.s.

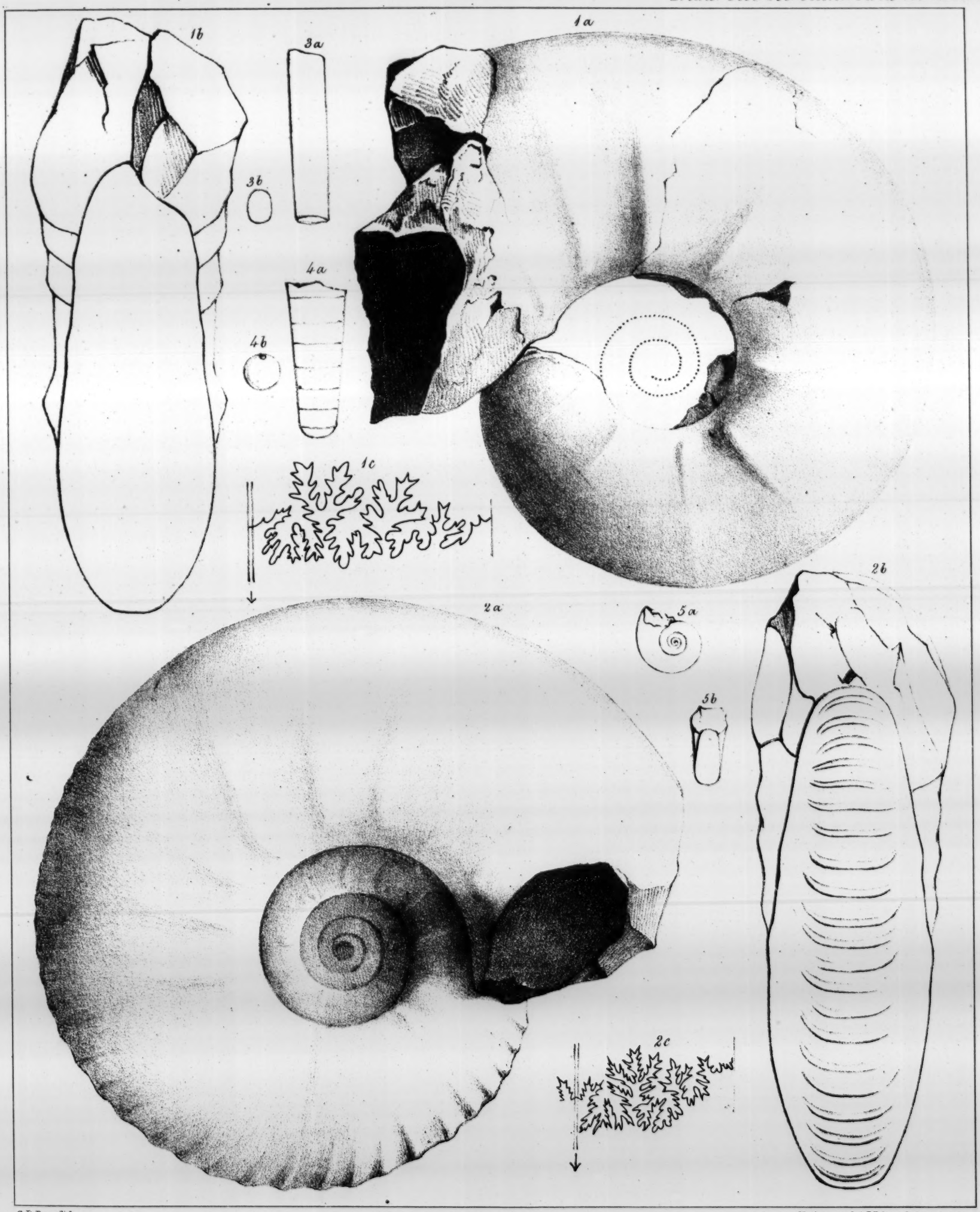


C.R.Bone lith.

Hullmandel & Walton Lithographers.

Fig. 1. a. b. c. d. *Ammonites Brahma n.s.*
2. a. b. c. d. " *Cunliffii n.s.*
3. a. b. c. " *Kayei. n.s.*
4. a. b. c. " *Cala. n.s.*
5. a. b. c. " *Varuna. n.s.*

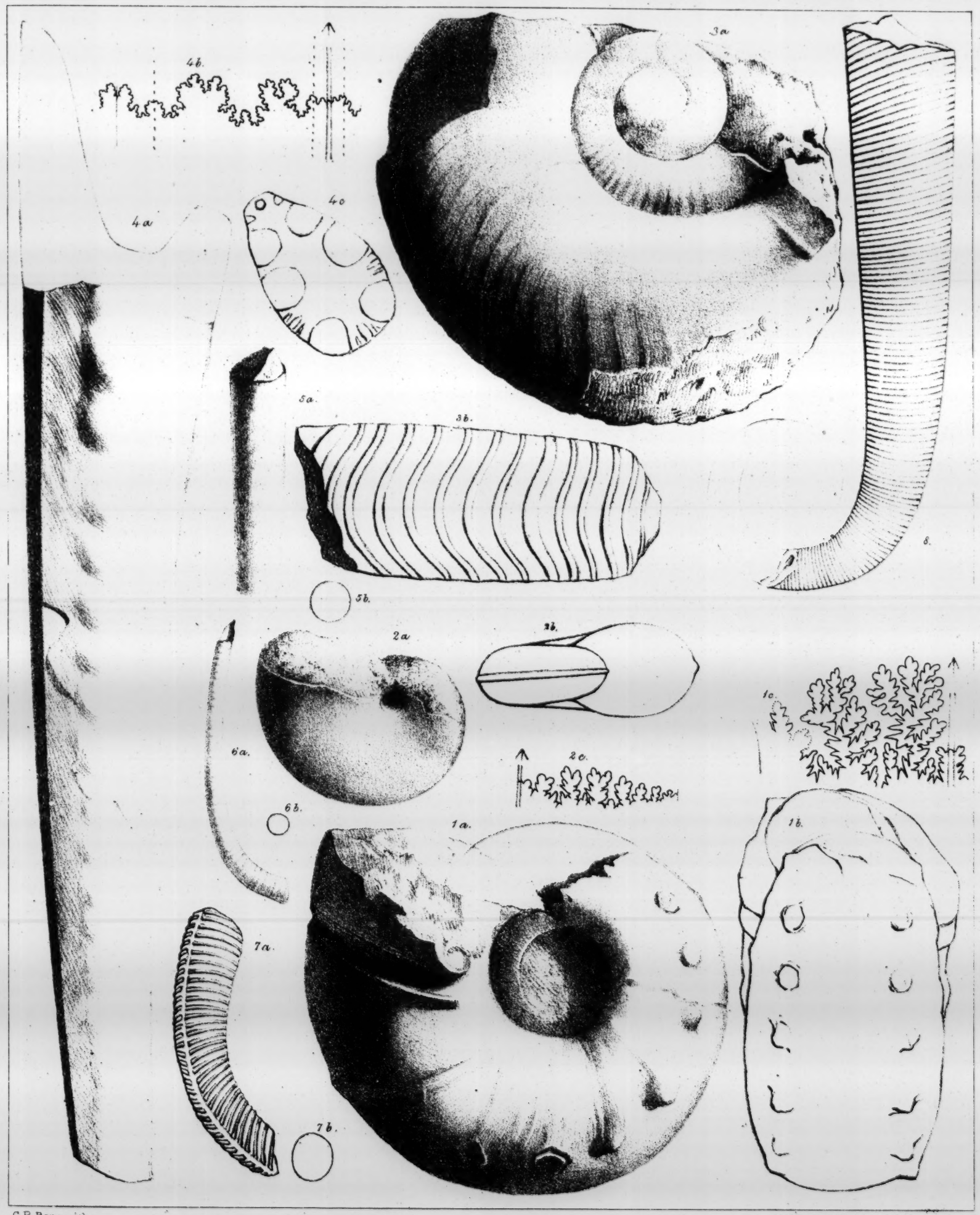
Fig. 6. a. b. c. *Ammonites Royanus. n.s.*
7. a. b. c. " *Nera n.s.*
8. a. b. c. " *Diphylloides. n.s.*
9. Ammonites? Indicus. n.s.



C.F. Bone lith.

Hullmandel & Walton Lithographers

1. a. b. c. *Ammonites Egertoni. n. s.*
2. a. b. c. *„ Chrishna. n.s.*
3. a. b. *Belemnites? fibula. n.s.*
4. a. b. *Belemnites.*
5. a. b. *Turrilites? planorbis. n.s.*

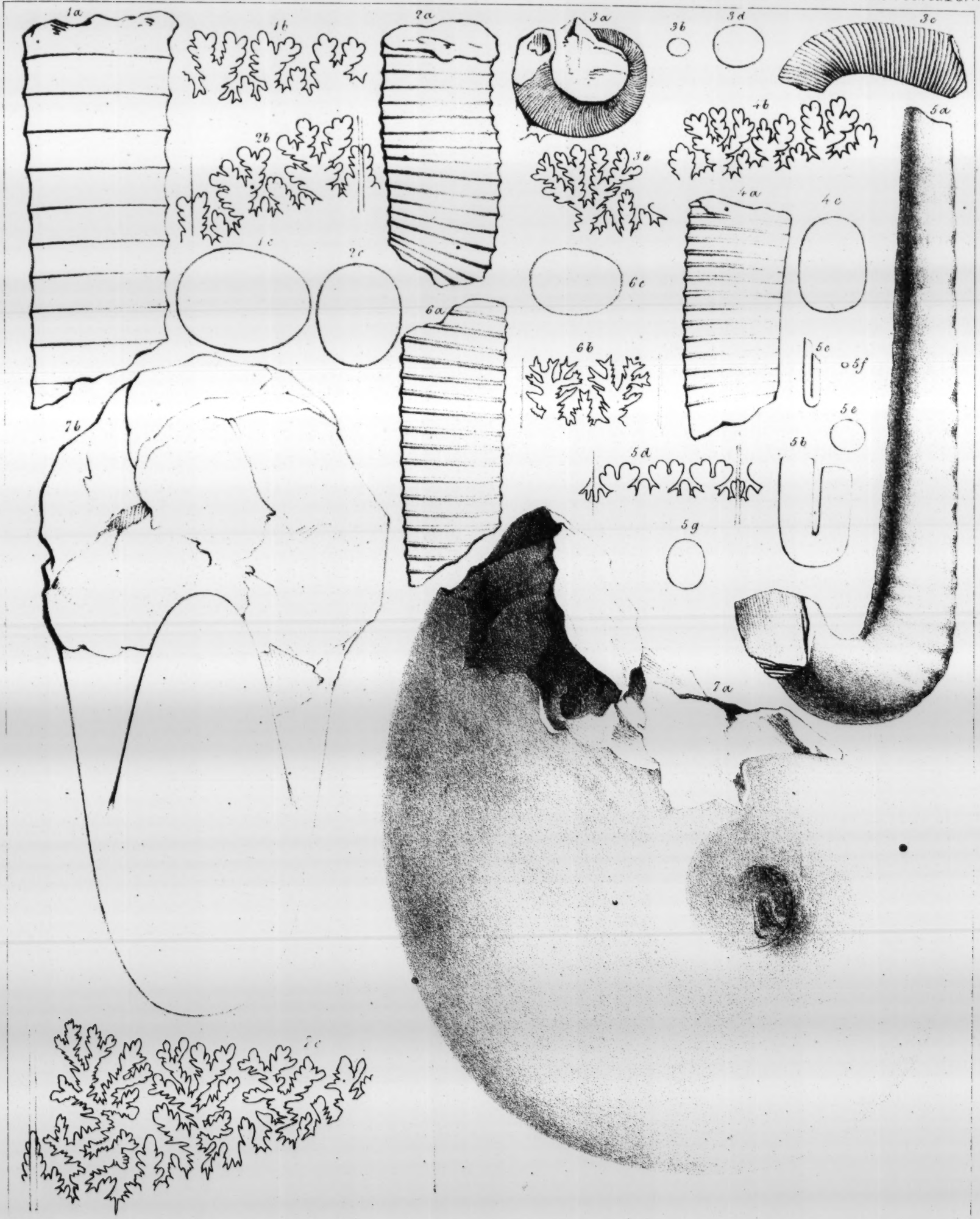


C.R.Bone Lith.

Hullmandel & Walton Lithographers

Fig: 1 a. b. c. Ammonites Menu. n. s
2 a. b. c. " Sugata n.s.
3. a. b " Gaudama n. s
4. a. b. c. Baculites vagina. n. s

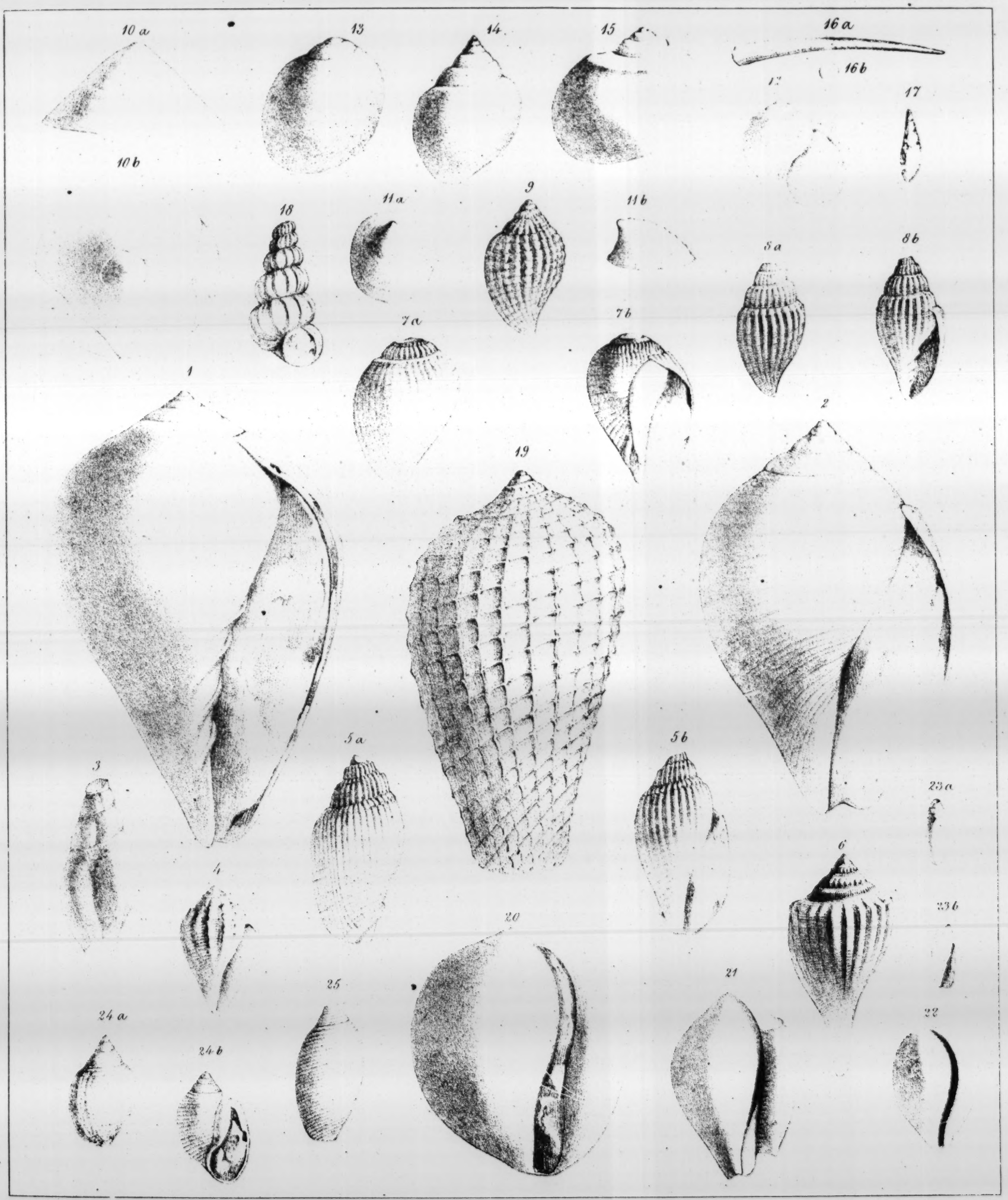
Fig: 5 a. b. Baculites teres n. s
6 a. b Hamites undulatus. n s
7. a. b " nereis. n. s.
8 " tenuisulcatus. n. s



C.F. Bone lith.

Fig. 1. a. b. c. *Hamites large-sulcatus. n.s.*
2. a. b. c. " *rugatus. n.s.*
3. a. b. c. d. e. " *tenuisulcatus. n.s.*
4. a. b. c. " *Indicus n.s.*

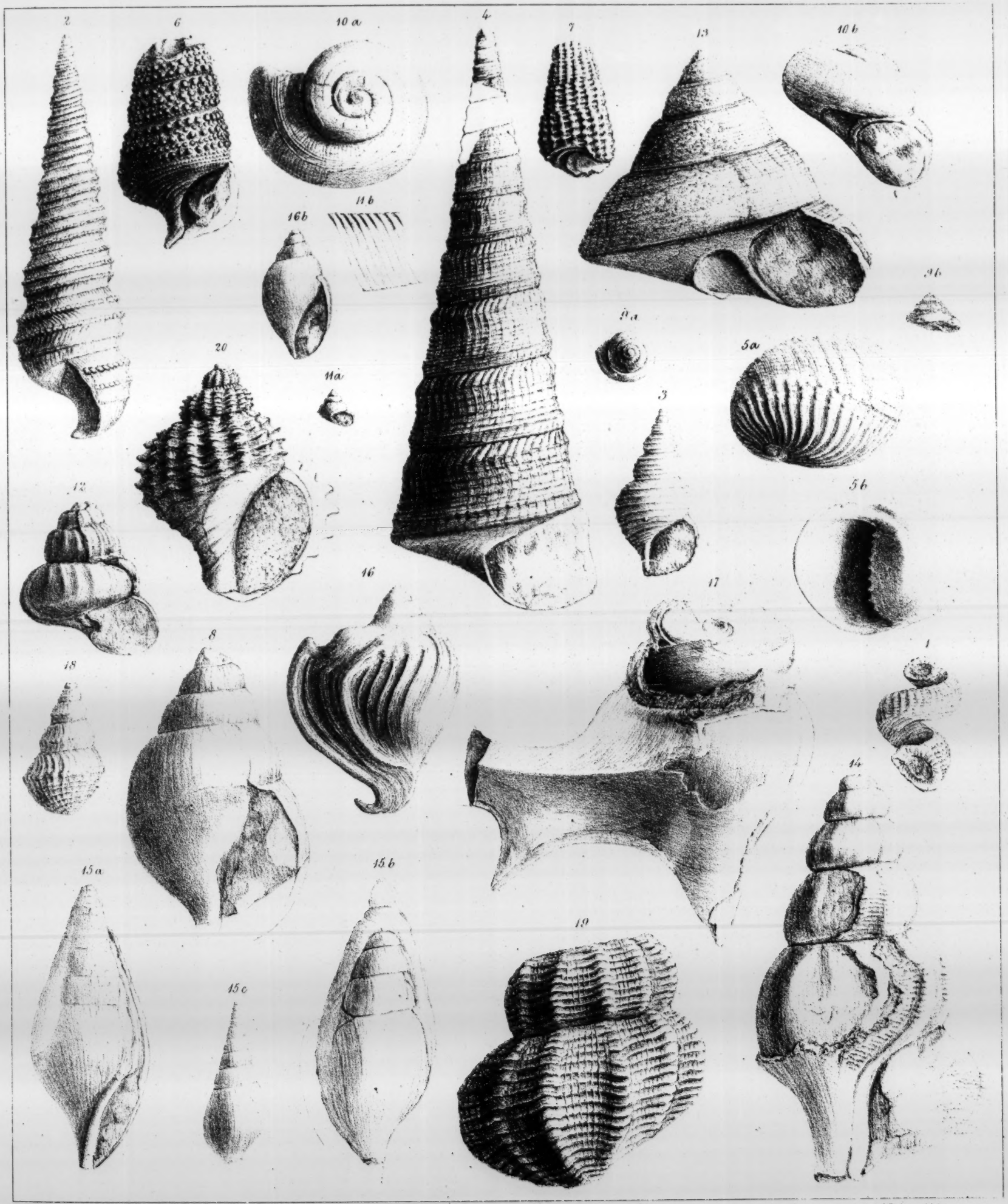
Fig 5. a. b. c. d. e. f. g. *Ptychoceras sipho. n.s.*
6. a. b. c. *Hamites subcompressus. n.s.*
7. a. b. c. *Ammonites Indra n.s.*



C.B. Bone lith.

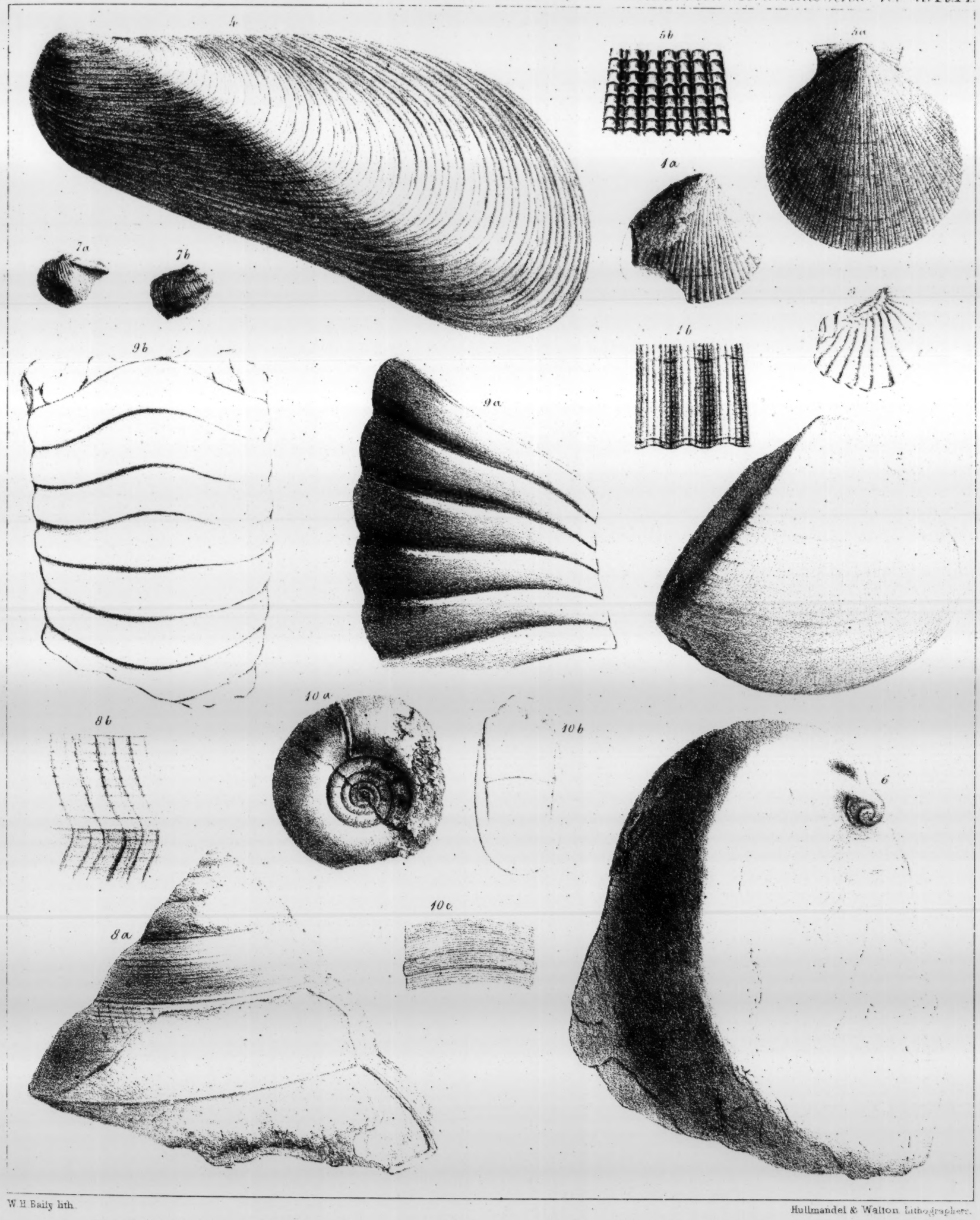
Hullmandel & Walton Lith. Printers

1. *Voluta pyriformis. n.s.*
2. " *purpuriformis. n.s.*
3. " *septemcostata. n.s.*
4. " *muricata. n.s.*
5 a b. " *candio. n.s.*
6. *cincta. n.s.*
7 a b. *breviplicata. n.s.*
8 a b. *citharina. n.s.*
9. " *radula. (G. Sow.y)*
10. a. b. *Calyptræa elevata. n.s.*
11. a. b. " *corrugata. n.s.*
12. *Natica obliquestriata. n.s.*
13. *Nerita oviformis. n.s.*
14. *Natica pagoda. n.s.*
15. *Nerita munita. n.s.*
16. a b. *Dentalium arcotinum. n.s.*
17. *Eulima antiqua. n.s.*
18. *Scalaria turbinata. n.s.*
19. *Pyrula pondicherriensis. n.s.*
20. *Cypræa Kayei. n.s.*
21. " *Newboldi. n.s.*
22. " *Cunliffei. n.s.*
23. a b. *Oliva vetusta. n.s.*
24. a b. *Tornatella labiosa. n.s.*
25. *curculio. n.s.*



W.H. Baily lith.

Fig. 1. *Vermetus anguis. n.s.*
2. *Turritella monilifera. n.s.*
3 „ *ventricosa. n.s.*
4. *Pondicherriensis. n.s.*
5. a. b. *Nerita ornata. n.s.*
6. *Cerithium sphæruliferum. n.s.*
7. „ *scalaroideum. n.s.*
8. *Phasianella? incerta. n.s.*
9. a. b. *Trochus arcotensis. n.s.*
10. a. b. „ *rotelloides. n.s.*
11. a. b. *Trochus radiatulus. n.s.*
12. „ *Rajah. n.s.*
13. *Pleurotomaria Indica. n.s.*
14. *Triton ataxus. n.s.*
15. a. b. c. *Rostellaria pallida. n.s.*
16. a. b. *Strombus uncatus. n.s.*
17. *Rostellaria scrutifera. n.s.*
18. „ *cancellifera. n.s.*
19. *Murex fluctuosus. n.s.*
20. „ *Pondicherriensis. n.s.*

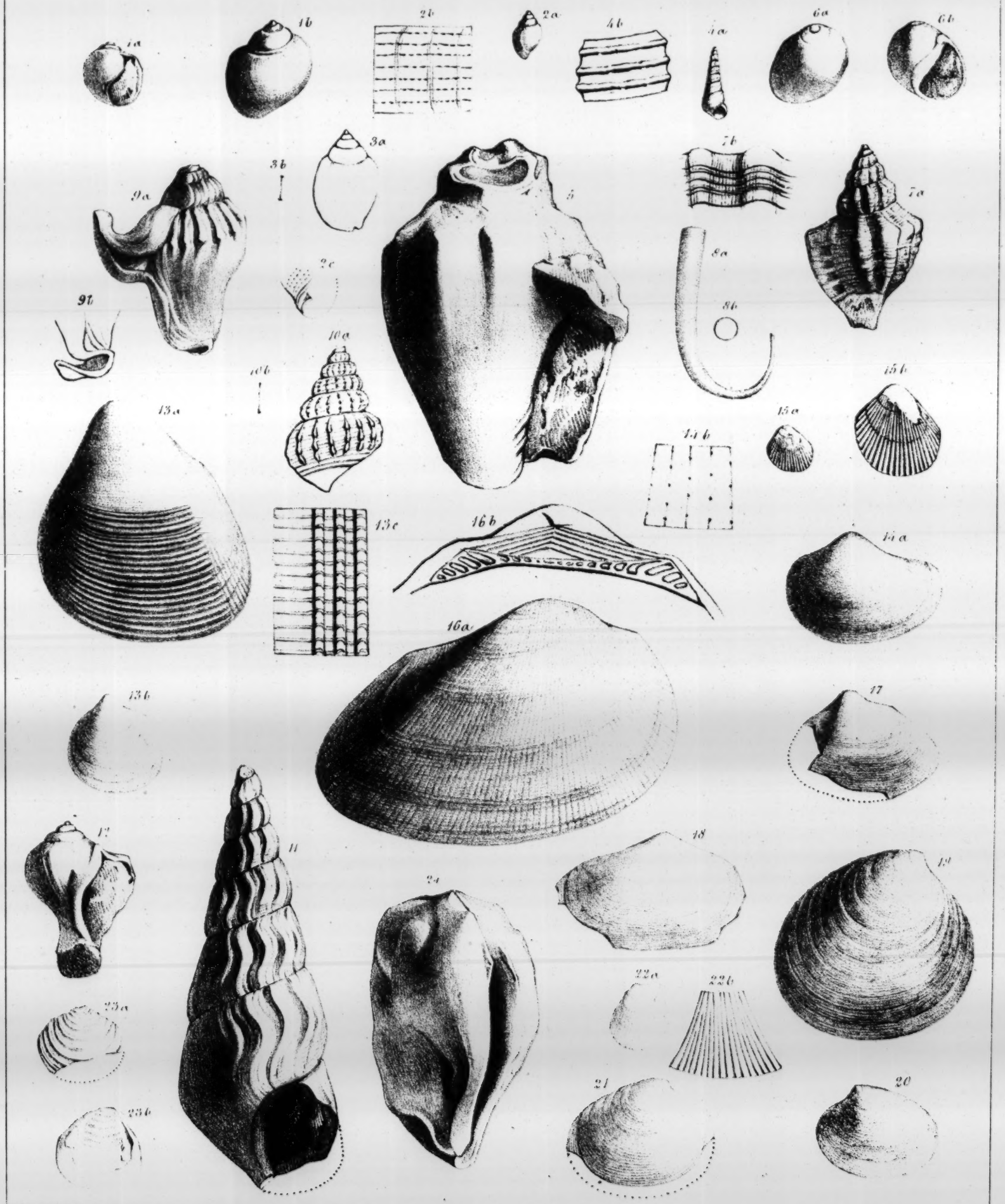


W H Baily lith.

Hullmandel & Walton Lithographers.

Fig. 1. a. b. *Cardita striata. n. s.*
2. *Arca abrupta. n. s.*
3. *Trigonia aliformis. Park.*
4. *Modiola typica. n. s.*
5. a. b. *Pecten verdachellensis. n. s.*

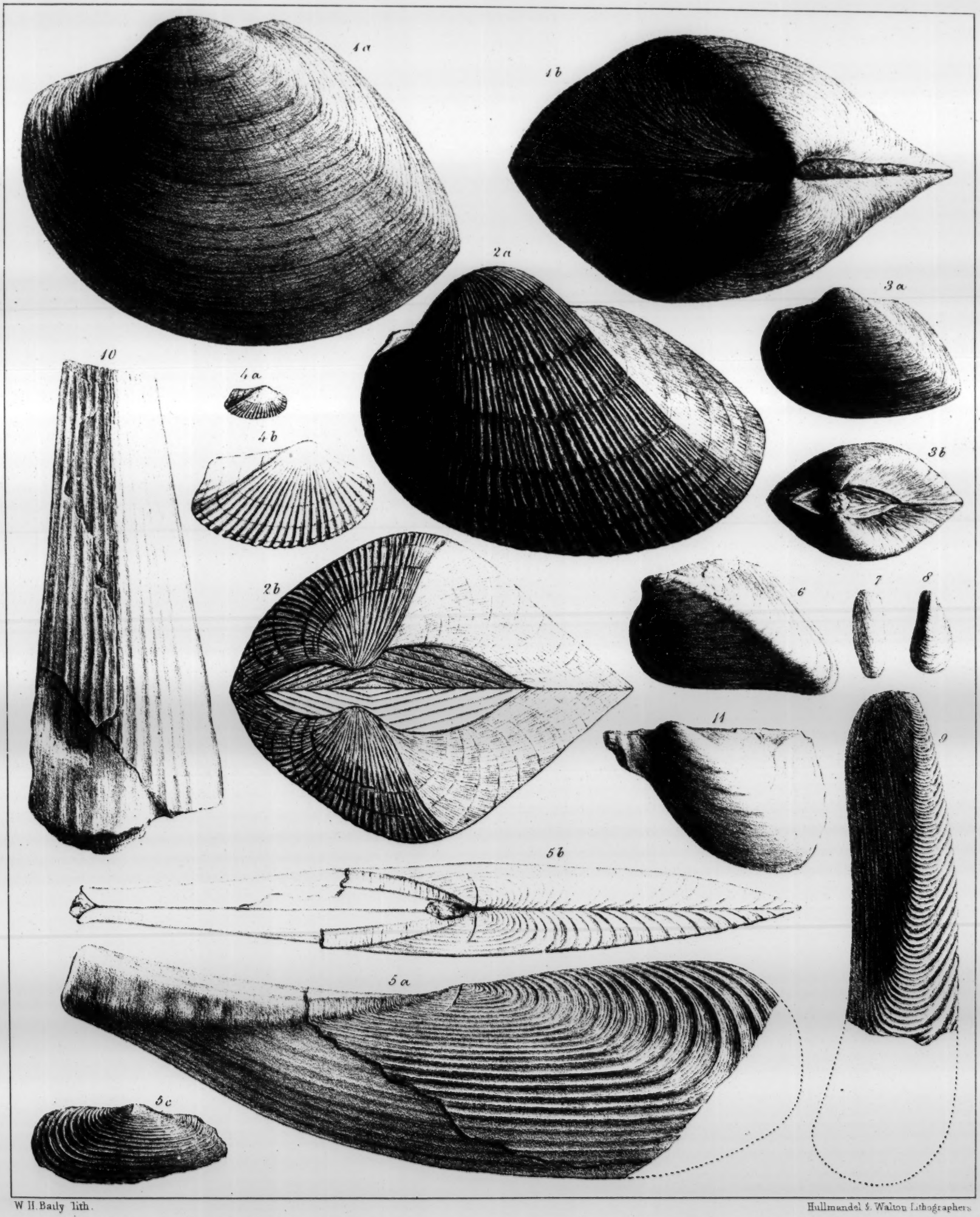
Fig. 6. *Gryphæa orientalis. n. s.*
7. a. b. *Natica rugosissima. n. s.*
8. a. b. *Pleurotomaria verdachellensis. n. s.*
9. a. b. *Ammonites Buddha. n. s.*
10. a. b. c. " *Sacya. n. s.*



W. Bone lith

Hullmandel & Walton lithographers

Fig. 1. a. b. *Natica saturnalis.* (G. Sow.)
2. a. b. c. *Tornatella semen.* n. s.
3. a. b. *Ringicula acuta.* n. s.
4. a. b. *Turritella Sowerbii.* n. s.
5. *Voluta Trinchinopolitensis.* n. s.
6. a. b. *Nerita compacta.* n. s.
7. a. b. *Marea Trinchinopolitensis.* n. s.
8. a. b. *Dentalium? hamatum.* n. s.
9. a. b. *Strombus contortus* (G. Sow.?)
10. a. b. *Cerithium Trinchinopolitensis.* n. s.
11. *Chemnitzia undosa* (G. Sow.)
12. *Pyrula cancellata?* n. s.
13. a. b. c. *Cardium altum* (G. Sow.)
14. a. b. *Poromya lata.* n. s.
15. a. b. *Cardium incomptum* (G. Sow.)
16. a. b. *Arca Trinchinopolitensis.* n. s.
17. *Mactra tripartita.* n. s.
18. *Psammobia inconspicua* (G. Sow.)
19. *Venus arcotensis.* n. s.
20. " *analoga.* n. s.
21. " *caimia.* n. s.
22. a. b. *Pecten virgatus* (Nilson)?
23. a. b. *Astarte planissima.* n. s.
24. *Ostrea amorpha* (G. Sow.)

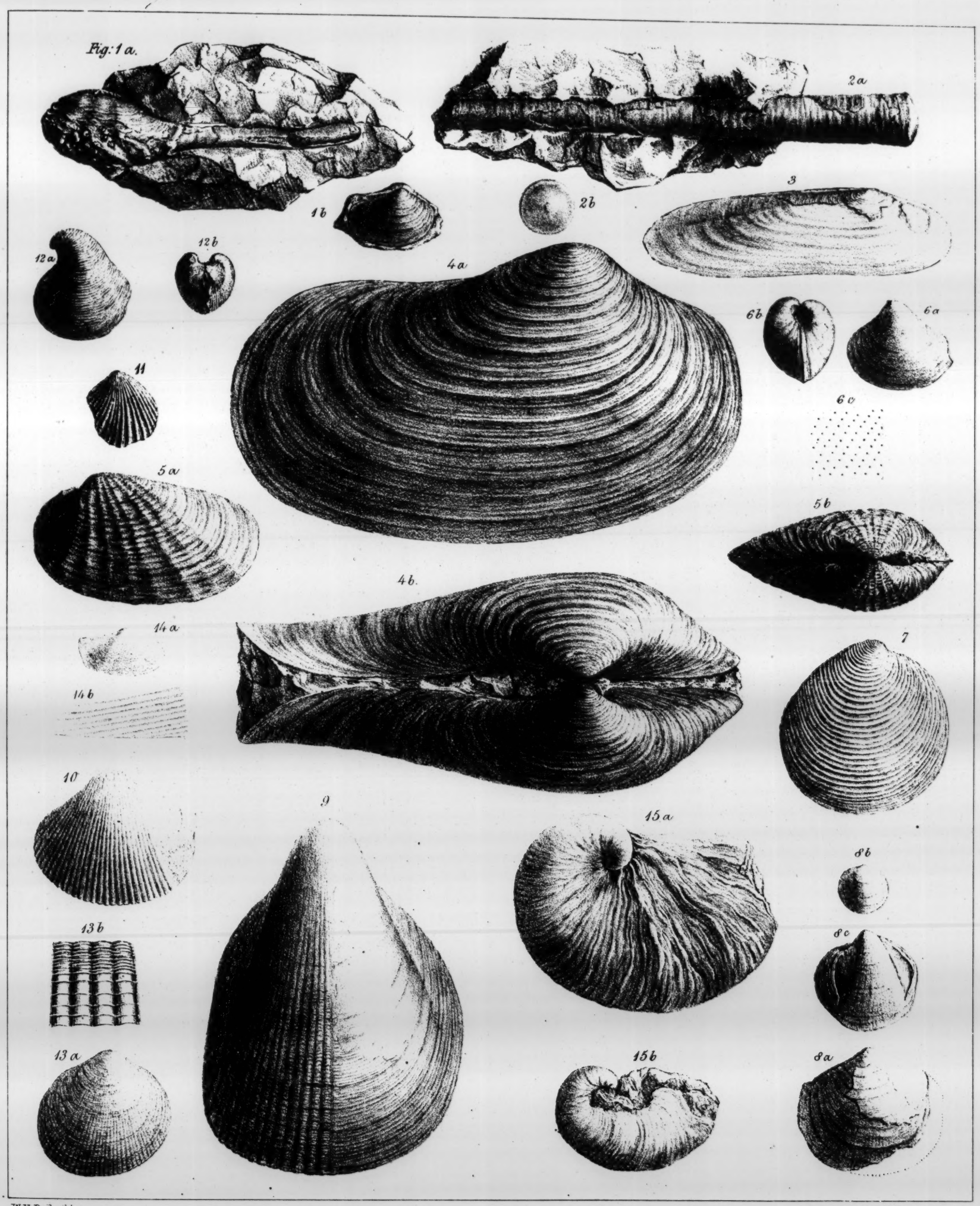


W. H. Baily lith.

Hullmandel & Walton Lithographers

Fig. 1. a. b. Arca Brahminica. n. s.
2. a. b. „ Japetica. n. s.
3. a. b. „ Gamana. n. s
4. a. b. „ Clellandi. n. s.
5. a. b. c. Anatina arcuata. n. s.
6. Mytilus pulcher. n. s.

Fig. 7. Mytilus cypris. n. s.
8. „ nitens. n. s.
9. „ flagelliferus. n. s.
10. Pinna arata. n. s.
11. Avicula nitida. n. s.

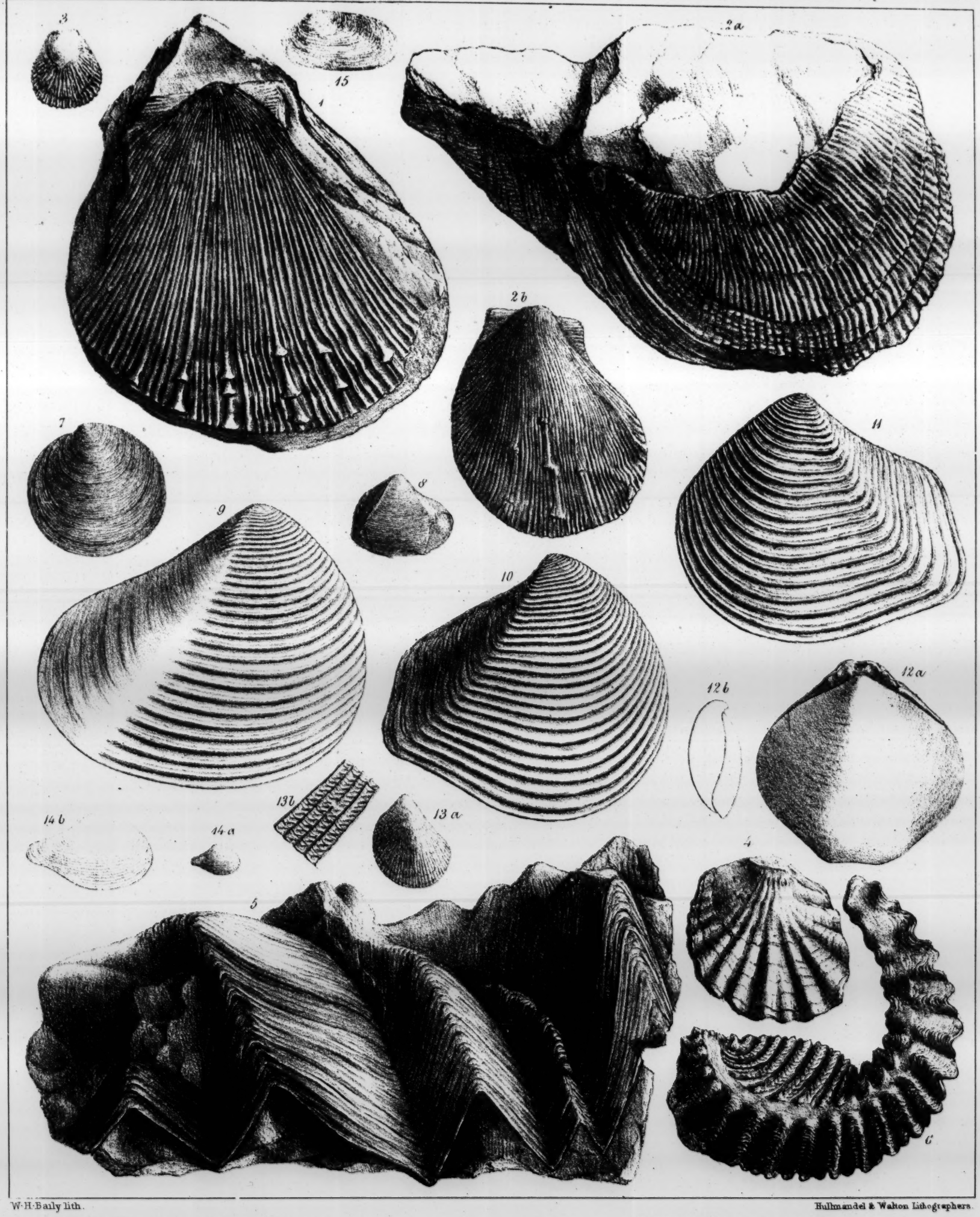


W.H.Baily dth

Hullmandel & Walton Lithographers.

Fig: 1. a. b. Gastrochæna semisulcata. n. s.
2. a. b. Fistulana aspergilloides. n. s.
3. Solecurtus obscurus. n. s.
4. a. b. Panopæa orientalis. n. s.
5. a. b. Pholadomya connectans. n. s.
6. a. b. c. Poromya globulosa. n. s.
7. Lucina jugosa. n. s.
8. a. b. c. „ fallax. n. s.

Fig: 9. Cardium bisectum. n. s.
10. „ lucerna. n. s.
11. Cardita orbicularis. n. s.
12. a. b. Isocardia subsinuata. n. s.
13. a. b. Pectanculus subauriculatus. n. s.
14. a. b. Nucula striatula. n. s.
15. a. b. Gryphæa stomatoidea. n. s.

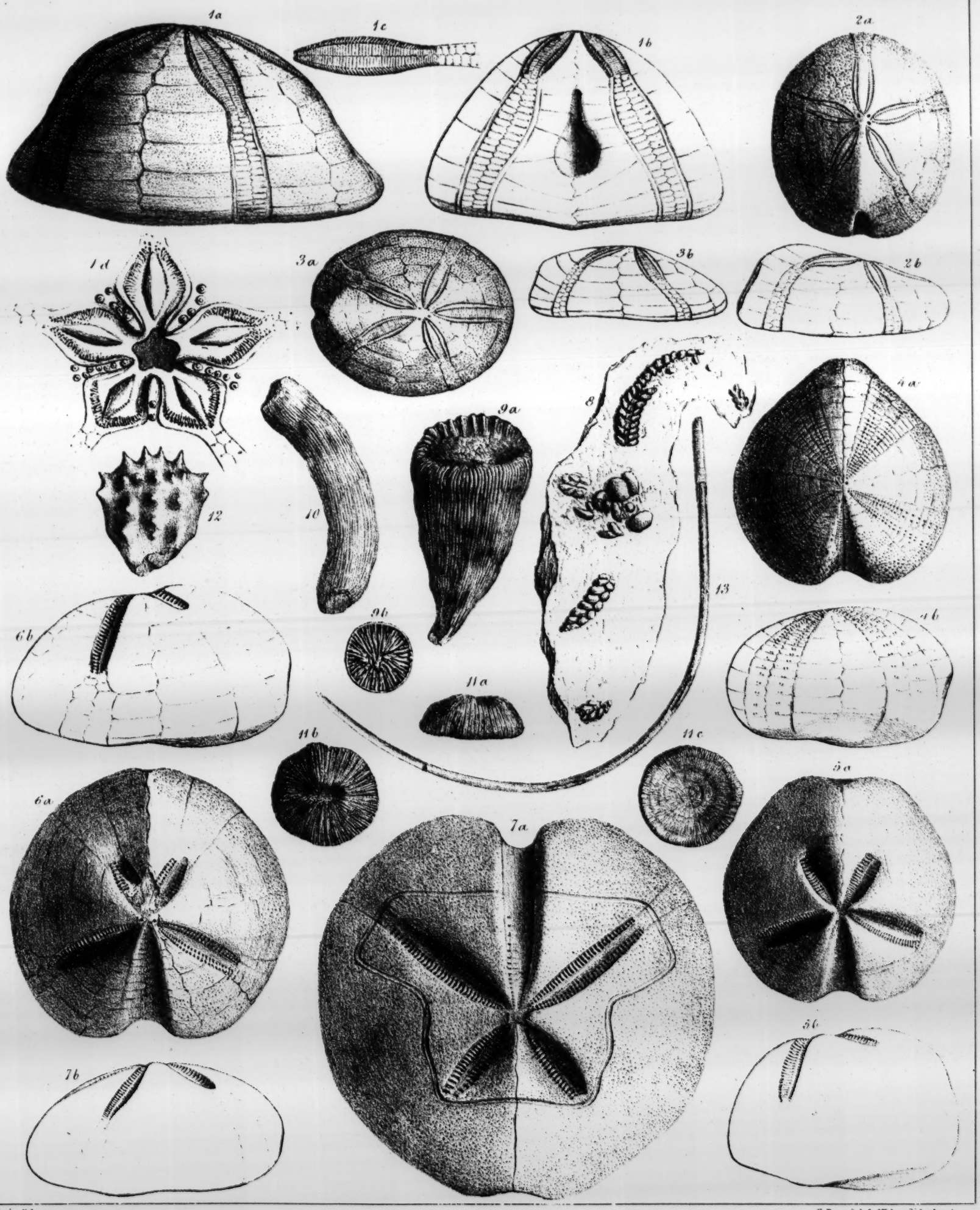


W. H. Baily lith.

Hullmandel & Walton Lithographers.

Fig 1. Spondylus subsquamosus. n.s.
2. a. b. „ calcaratus. n.s.
3 Plicatula multicostata. n.s.
4. „ 7 costata. n.s.
5. Ostrea pes leonis. n.s.
6. „ tegulanea. n.s.
7. Artemis lenticularis. n.s.

Fig 8. Cardium intersectum. n.s.
9. Trigonia semiculta. n.s.
10. „ suborbicularis. n.s.
11. „ orientalis. n.s.
12. a. b. Terebratula arabilis. n.s.
13. a. b. Lima oblique striata n.s.
14. a. b. Corbula striatuloides. n.s.
15. Tellina Pondicherriensis. n.s.



W H Baily lith.

Hullmandel & Walton Lithographers

Fig 1. a. b. c. d. *Nucleolites elatus* n.s.
2. a. b. " *testudo* n.s.
3. a. b. " *planatus* n.s.
4. a. b. *Holaster Indicus* n.s.
5. a. b. *Brissus rana* n.s.
6. a. b. " *inæqualis* n.s.
7. a. b. " *expansus* n.s.
8. *Ophiura Cunliffii* n.s.
9. a. b. *Turbinolia arcotensis* n.s.
10. *Cladocora sp?*
11. a. b. c. *Fungia filimentosa* n.s.
12. *Carapace of a Crab.*
13. *Dentrupa longissima* n.s.

18 19 20 21 22 23 24 25

30 31 32 33

ORANGE RIVER

BUSHMANS KAROO

Koussie R. Komaggas M. Zwartbooies R. Spoek R. Bitter R. Groen R. Kromme R. Kabis Spioen B.

Nichells Bay

Kamies Berg

Desert Country

Hartebeeste R. Olifants Kloof R. Leeuwenkuit R. Zout R. Ongers R.

CRIQUA TOWN

Vaal R. Modder Riet River Nu Gariep or Orange River Honde Klaas R.

COLESBERG

VICTORIA RICHMOND

Brakke R. Zak R. Dmaal R.

L. Fish R. Fisanders R. Rhenosters R. L. Riet R. Karee R. Great Reit R. Kleine Reit R.

ONDER ROGGEVELD MIDDEL ROGGEVELD KLEINE ROGGEVELD NIEUWVELD

Kleine Roggeveld Nieuwveld Berge

BEAUFORT

Koudevelds Berge

GRAAF REINET

Zwart R. Buffels R. Bloed R. Dwyka R. Gamka R. Zout R. Karee R. Bull R.

GREAT KAROO

Baron-ragged Country

Olifants R. Olifants River Bantam River Oorlogs Kliprug R. Doorn R. Bieedouw Beeren Legement R. Verloren V. Lamberts Bay C Deseada St Helena Bay Saldanha Bay Berg River Groen R. Great Berg River Cold Bokkeveld Piquetberg Mts

CLANWILLIAM TULBACH CERES WITTEBERG MALMESBURY PARL CAPE TOWN STELLENBOSCH Wynberg Constantia Hottentots Holland Mts Simons Town False Bay Cape Point Table Mt Devils Peak Lion's Head Signal Hill Green Point Table Bay Robben I. Villiers Dorp Zonder End Mountain Zonder End River Genadendaal Caledon Mt Rooiberg C. Hangklip Houw Hoek Mts Hottentots Bay Bot R. Bay R. Palmiet R. Steenbras R. Lourens R. Eerste R. Lotus R. Sir Lowry's Pass Hottentots Holland Kloof

CALVINIA

YANTAM

SECTION LINE

THE

Oliphants R. Donkins Bay C Donkin

Kleine Roggeveld

Touw River

Kamanassie Mts Montagu Pass Outeniqua Mts Kerkhouts R. Duiwe R. Touw R. Oliphants R. Gamka R. Zout R. Olifants R. Karee Mts Karee R. Montagu Pass Outeniqua Mts Kerkhouts R. Duiwe R. Touw R. Oliphants R. Gamka R. Zout R. Olifants R. Karee Mts Karee R.

RIVERSDALE ALIWAL SOUTH GEORGE KNYSNA Knysna R. Gt Brak R. Mossel Bay Fish Bay Flesh Bay Plettenberg Bay Cape Delgado C. St Francis Gamtoos R. Van Staden's R. Port Elizabeth Uitenhage Zwartkops R. Sundays R. Bushmans R. Kowie R. Bathurst Grahamstown Fish R. Great Fish R. Kat R. Keiskamma R. Buffalo R. Kei R. Amatola Mts Winterberg Mts Stormberg Mts Zuurberg Mts Cradock Mts Bruintjes Hoogte Mts Sneeuw Berg Mts Nieuwe Veld Berge Koudevelds Berge Camdeboo Mts Sneeuw Berg Mts Nieuwe Veld Berge Koudevelds Berge Camdeboo Mts

REFERENCES

Sand. Stone &c (Wood Coal & Reptilian remains	16
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Granite	9
Tertiary	8
Lias ?	7
Conglomerate	6
Carbonifirous ?	5
Upper Silurian ?	4

GEOLOGICAL MAP OF SOUTH AFRICA

BY

Andrew Geddes Bain.

ANGRA PEQUENA

CRIQUA TOWN

Vaal R.

OWINBURG

Modder River

Kaal Spruit

BLOEMFONTEIN

Riet River

Nu Gariep or Orange River

Hondeklaas R.

Caledon River

Orange River

Drakensberg or Quathlamba Mts.

Weenen

Military Post

Umgaani R.

PIETERMARITSBURGH

Umcomaas R.

D'URBAN

PORT NATAL

Lecuwenkuit R.

Zout R.

Ongers R.

SMITHFIELD

COLESBERG

ALIWAL

Witte Bergen

Kraai River

T'Sitchi R.

Umzimculu R.

Umzimvubu R.

Umtata R.

Umtamvoboo or St. Johns River

Unscaba R.

BURGHERS DORP

Sterkstroom

Rooder

Zwart Kei R.

Indaay R.

Buffalo R.

Bashee R.

Great Kei R.

VICTORIA

RICHMOND

Compass Berg

Swart Kop

Burghersdorp

SECTION LINE No. II.

CRADOCK

WHITTLESEA

Great Winterberg

AMATEMBUS

Amatola Mts.

Gwanda Kop

Gaika Kop

Fort Hare

Fort White

KING WILLIAMS TOWN

EAST LONDON

Fort Murray

Keiskama R.

Buffalo R.

Great Fish R.

BATHURST

Kowie Mouth

Kowie R.

Bushmans R.

Kariega R.

Oliphants Hoek

Point Formosa

Algoa Bay

Sundays R.

Cape Recife

Zwart R.

Buffel R.

Koudeveld Berg

Camdeboo

BEAUFORT

GRAAF REINET

Zuur R.

Bull R.

Kleine Zwart R.

Groote Zwart R.

Baviaans R.

Kromme R.

Gamtoos R.

Van Stadens R.

Tarka R.

Klipplaats R.

Fullers R.

Enons

Groote Rivier

Kouga Mts.

Outeniqua Mts.

Kamanassie R.

Kaaimans R.

Gouritz R.

Touw R.

Duiwenhoks R.

Kromme R.

Kareedouws R.

Olifants R.

Kaysers R.

Plettenberg Bay

Cape Delgado

Keurbooms R.

Gt. Brak R.

Klein Brak R.

Mossel Bay

C. St. Francis

GEORGE

UITENHAGE

PORT ELISABETH

Zuurberg Mts.

Zuurberg R.

Sundays R.

Kariega R.

Bushmans R.

Kowie Mouth

Point Formosa

Algoa Bay

Cape Recife

Great Fish R.

Keiskama R.

Buffalo R.

Great Kei R.

Umtata R.

Umtamvoboo or St. Johns River

Unscaba R.

Umzimvubu R.

Umzimculu R.

T'Sitchi R.

Umzimcululu R.

Umgaani R.

Umcomaas R.

Ibi R.

PIETERMARITSBURGH

D'URBAN

PORT NATAL

Military Post

Weenen

Drakensberg or Quathlamba Mts.

Witte Bergen

Orange River

Caledon River

Riet River

Modder River

Kaal Spruit

Vaal R.

OWINBURG

CRIQUA TOWN

ANGRA PEQUENA

Lecuwenkuit R.

Zout R.

Ongers R.

Hondeklaas R.

Nu Gariep or Orange River

SMITHFIELD

COLESBERG

ALIWAL

Kraai River

BLOEMFONTEIN

Kaal Spruit

Riet River

Modder River

VICTORIA

RICHMOND

BEAUFORT

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SECTION LINE No. II.

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Kromme R.

Zwart R.

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Camdeboo

Zuur R.

Bull R.

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Buffalo R.

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Umtamvoboo or St. Johns River

Unscaba R.

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PIETERMARITSBURGH

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ANGRA PEQUENA

Lecuwenkuit R.

Zout R.

Ongers R.

Hondeklaas R.

Nu Gariep or Orange River

SMITHFIELD

COLESBERG

ALIWAL

Kraai River

BLOEMFONTEIN

ORANGE RIVER

Desert Country

BUSHMANS KAROO

Koussie R.

Komaggas M.

Zwartbanies R.

Spoek R.

Bitter R.

Michells Bay

Groen R.

Kromme R.

Kabis

Spioen R.

Kamies Berg

CALVINIA

HANTAM

Bontam River

ONDER-BOKKEVELD

Oorlogs

Oliphants R.

Oliphants River

Donkins Bay
C Donkin

Bieedouw

Doorn R.

Lamberts Bay

Verlooren V.

CLANWILLIAM

C Descada

St Helena Bay

Saldanha Bay

Great Berg River

TULBACH

CERES

MALMESBURY

CAPE TOWN

SIMONSTOWN

False Bay

Cape Point

C. Hangtip

Sandown Bay

C. Madge

Walkers Bay

Danger Pt.

CALEDON

Zonder End River

Genadendal

Mc Babylon

Cape L'Agulhas

THE SECTION LINE

Hartebeeste R.

Oliphants Kloof R.

Leeuwenkuit R.

Zout R.

Brakke R.

Zak R.

Dnaal R.

Onder R.

VICTORIA

RICHMOND

COLESBERG

Ronde Klaas R.

Xu Garicep or Orange River

Vaal R.

Modder River

Riet River

Ongers R.

Tarka R.

UNDER ROGGEVELD

Misroad R.

Lish R.

Rhenoster R.

Kilander R.

L. Riet R.

Karee R.

NIEUWVELD

MIDDEL ROGGEVELD

Great Kraai R.

Kleine Kraai R.

BEAUFORT

Kleine Roggeveld

Great Roggeveld

Buffels R.

Gamka R.

Dwyka R.

Groot R.

Kloof R.

Ongers R.

Bull R.

Zwart R.

Kouduelds Berg

GRAAF REINET

Camdeboo

Sneeuw Berg

Burghersdorp

Stormberg

Winterberg

Bamboo Berg

Kamies Berg

Olifants R.

Kamies Berg

Montagu Pass

Kyskamma R.

Kyskamma Dorp

Bloukrans R.

Zuurberg Mt.

Zuurberg

Kromme R.

Sunday R.

Zwartkops R.

Baakens R.

Coega R.

Van Staden R.

Gamtoos R.

Cape Recife

Algoa Bay

PORT ELIZABETH

UITENHAGE

Plettenberg Bay

Cape Delgado

C. St Francis

Mossel Bay

Gr. Brak R.

Keymans R.

Keysers R.

Fish Bay

Gauritz R.

RIVERSDALE

ALIWAL SOUTH

Port Beaufort or
St Sebastians Bay
C Infantas

Duyvenbosch R.

Slange R.

Duiwenhoks R.

Touw River

Gouritz River

Kaffir Kuil R.

Attaquas Kloof

Outeniqua Mts.

Zwartberg

Langeberg

Lange Kloof

Hex River

Breede R.

Riet R.

Modder R.

Rooderberg

Witwatersrand

Magaliesberg

Compass Berg

Bushmans R.

Kaffir Kuil R.

Kaffir Kuil

Burghersdorp

Stormberg

Winterberg

Bamboo Berg

Kamies Berg

Olifants R.

Kamies Berg

Montagu Pass

Kyskamma R.

Kyskamma Dorp

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Witwatersrand

Magaliesberg

Compass Berg

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Kaffir Kuil R.

Kaffir Kuil

REFERENCES

Sand. stone &c	Wood Coal & Reptilian remains	16
	Reptilian remains	15
	Sandstone & Slate containing Fucoidites & Lineal Plants	14
	Port Beaufort Grit	13
	Blue Slate containing do	12
	Greenstone	11
	Claystone Porphyry	10
	Granite	9
	Tertiary	8
	Lias ?	7
	Conglomerate	6
	Carboniferous ?	5
	Upper Silurian ?	4
	Lower Silurian ?	3
	Clayslate	2
	Gneiss	1

Ch.s Achilles lith.

GEOLOGICAL MAP OF SOUTH AFRICA

BY

Andrew Geddes Bain.

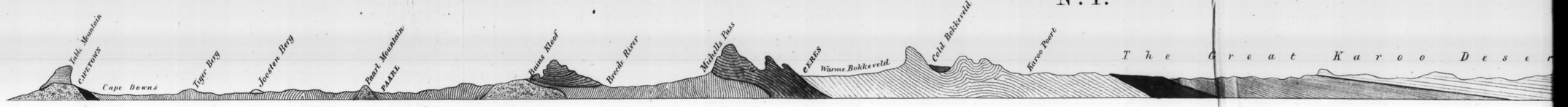
10 5 0 10 20 30 40 50 60 70 80 90 100 MILES

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GEOLOGICAL SECTIONS OF SOUTH AFRICA

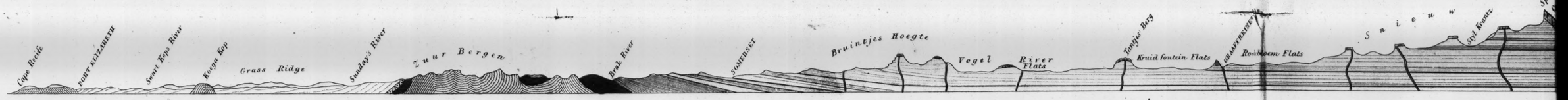
BY ANDREW GEDDES BAIN.

Nº I.



Section from Table Mountain to Middel Roggevdd

Nº II.



Section from Cape Recife to Lower Zekoe River near Orange River

Nº III.



Section from Kowie mouth to Caledon Rvr

Nº V.



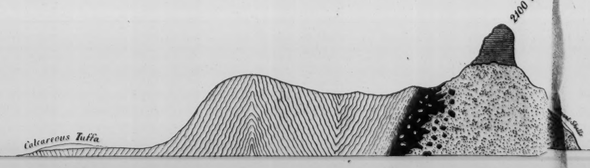
Contorted upper Silurian Sand-stone, Karoo Poort.

Nº VI.



Contorted Carboniferous Sandstone, Burnt Kraal *near* Grahams Town.

Nº IV.



Sections of Lion's Hill.

Nº VII



Fault in the Lacustrine Strata, Buffels River, Great Karoo.

REFERENCES.

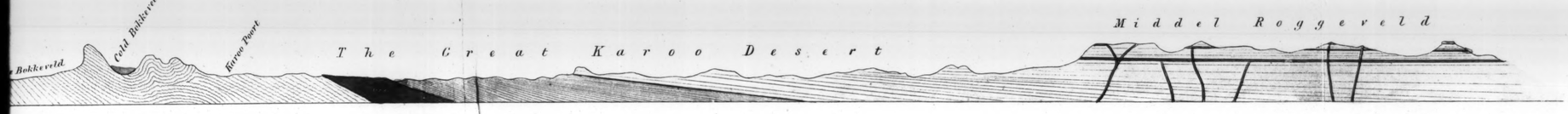
- *Tertiary*
- *Lias?*
- *Conglomerate*
- *Carboniferous?*
- *Upper Silurian?*
- *Lower Silurian?*
- *Clayslate*

Transact. Geol. Soc. 2 Ser. Vol. VII. Pl. XXI.

AL SECTIONS OF SOUTH AFRICA.

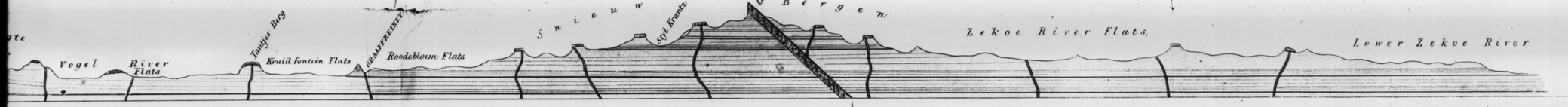
BY ANDREW GEDDES BAIN.

Nº I.



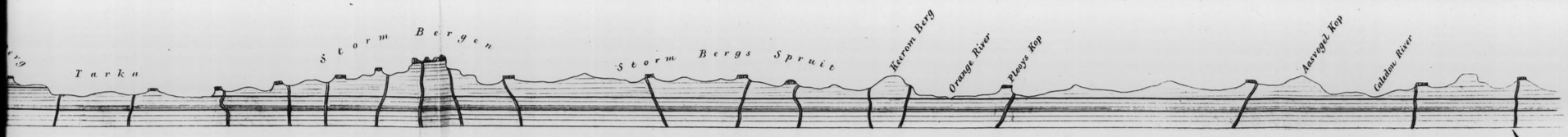
Section from Table Mountain to Middel Roggeveld

Nº II.



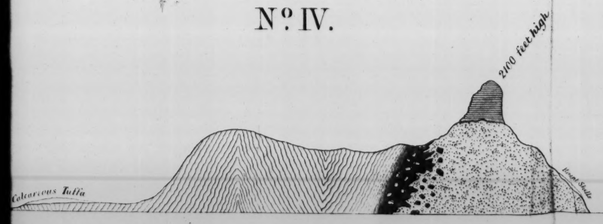
on from Cape Recife to Lower Zekoe River near Orange River

Nº III.



Section from Kowie mouth to Caledon River

Nº IV.



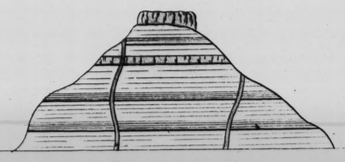
Sections of Lion's Hill.

Nº VII



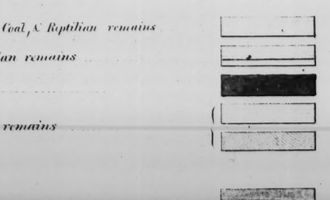
Fault in the Lacustrine Strata,

Nº VIII.



Mountain in the Amatembu *Country,*

REFERENCES.





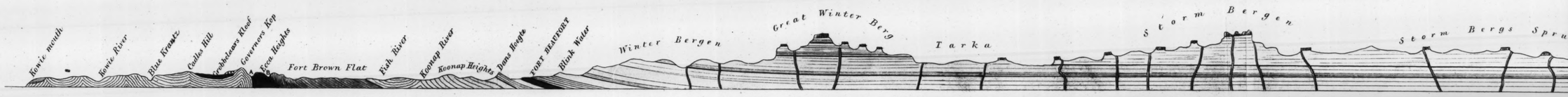
Section from Table Mountain to Middel Roggeveld

Nº II.



Section from Cape Recife to Lower Zekoe River near Orange River

Nº III.



Section from Kowie mouth to Caledon River

REFERENCES.

- *Tertiary*
- *Lias?*
- *Conglomerate*
- *Carboniferous?*
- *Upper Silurian?*
- *Lower Silurian?*
- *Clayslate*
- *Gneiss*

Nº V.



Contorted upper Silurian Sand-stone,
Karoo Poort.

Nº VI.



Contorted Carbonaferous Sandstone, Burnt Kraal
near Grahams Town.

Nº IV.



Sections of Lion's Hill.

Nº VII



Fault in the Lacustrine Strata,
Buffels River, Great Karoo.

Scale for Vertical extents.

0 1800 3600 5400 7200 9000 10800 12600 14400 16200 feet

Scale for Horizontal extents.

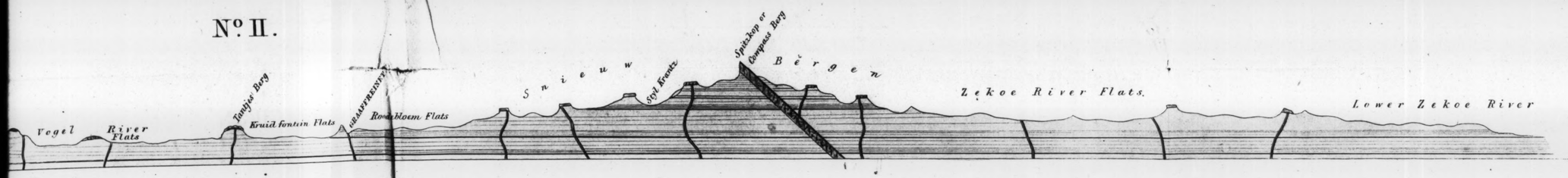
6 3 0 6 12 18 24 30 36 Miles

NOTE. The above scales are only applicable to sections Nº 1. 2. & 3.



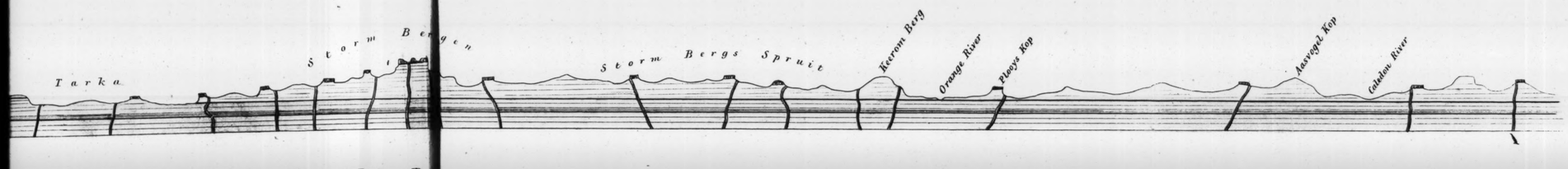
Section from Table Mountain to Middel Roggeveld

Nº II.



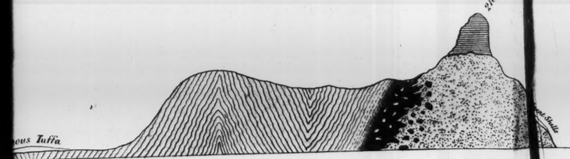
from Cape Recife to Lower Zekoe River near Orange River

Nº III.



Section from Kowie mouth to Caledon Ri

Nº IV.



Sections of Lion's Hill.

Scale for Vertical extents.

Scale for Horizontal extents.

6 3 0 6 12 18 24 30 36 Miles

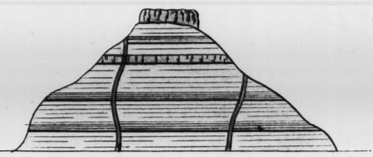
NOTE. The above scales are only applicable to sections Nº 1 2 & 3.

Nº VII



Fault in the Lacustrine Strata,
Buffels River, Great Karoo.

Nº VIII.



Mountain in the Amatembu Country,
shewing 2 beds of Greenstone & 2 dikes of different ages.

REFERENCES.

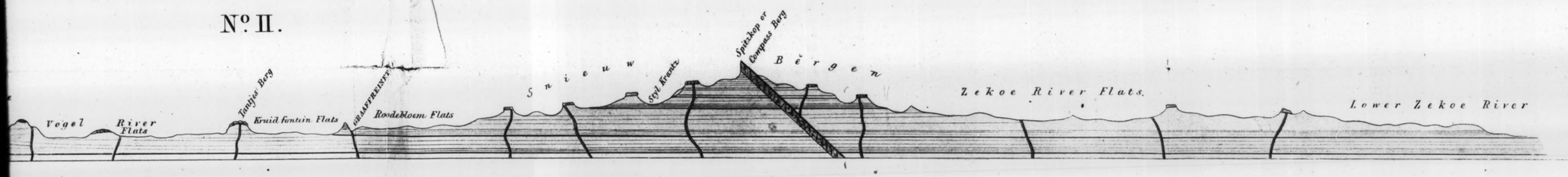
- Sandstone &c. { Wood, Coal, & Reptilian remains / Reptilian remains
- Fort Beaufort Grit
- Sandstone &c. Plant-remains
- Greenstone
- Claystone Porphyry
- Granite

Printed by Malby & Sons.



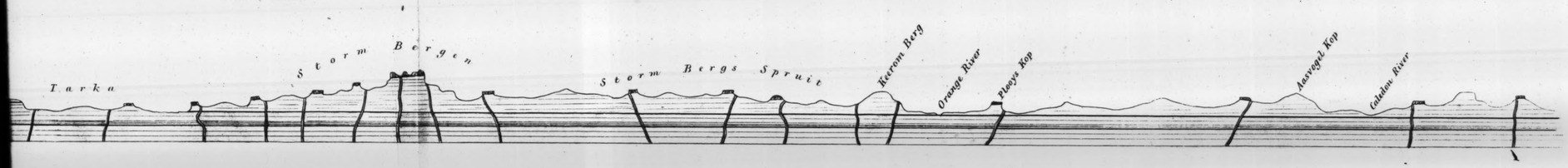
Section from Table Mountain to Middel Roggeveld

Nº II.



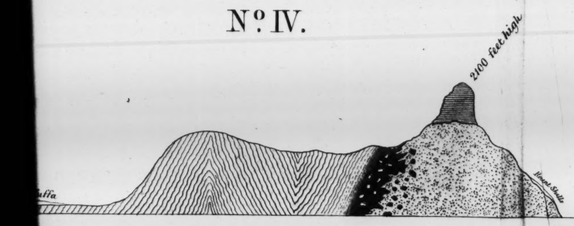
from Cape Recife to Lower Zekoe River near Orange River.

Nº III.



Section from Kowie mouth to Caledon River

Nº IV.



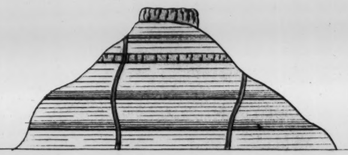
Sections of Lion's Hill.

Nº VII



Fault in the Lacustrine Strata,
Buffels River, Great Karoo.

Nº VIII.



Mountain in the Amatembu *Country,*
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REFERENCES.

- *Sandstone &c.* — *Wood, Coal, & Reptilian remains*
- *Sandstone &c.* — *Reptilian remains*
- *Fort Beaufort Grit*
- *Sandstone &c. Plant-remains*
- *Greenstone*
- *Claystone Porphyry*
- *Granite*

Scale for Vertical extents.

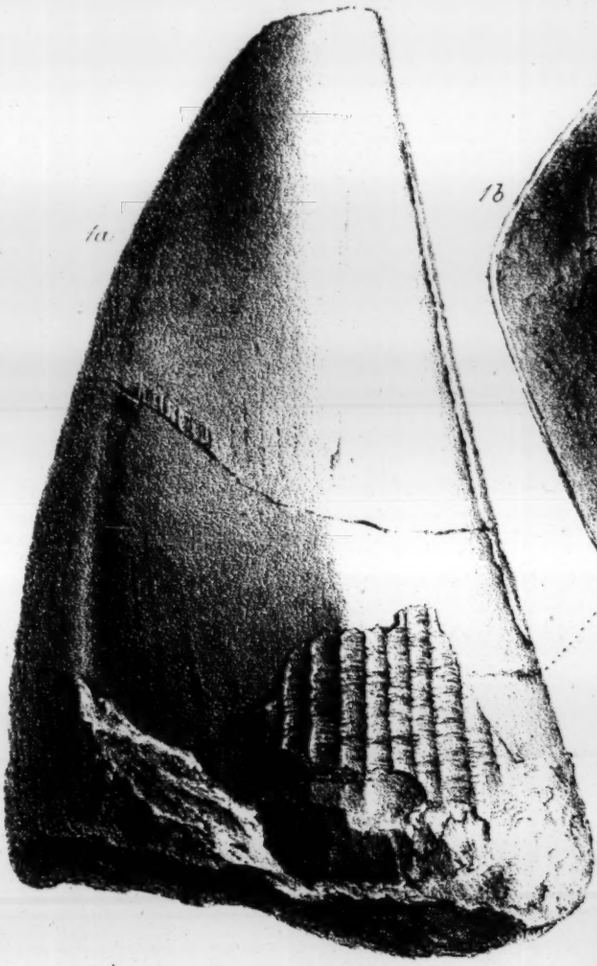
0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000 14000 15000 16000 feet

Scale for Horizontal extents.

6 3 0 6 12 18 24 30 36 Miles

NOTE.—The above scales are only applicable to sections Nº I 2 & 3.

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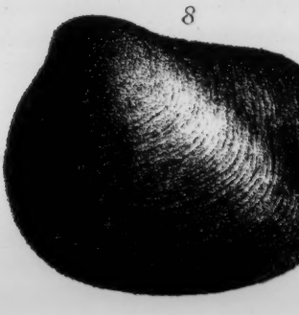




















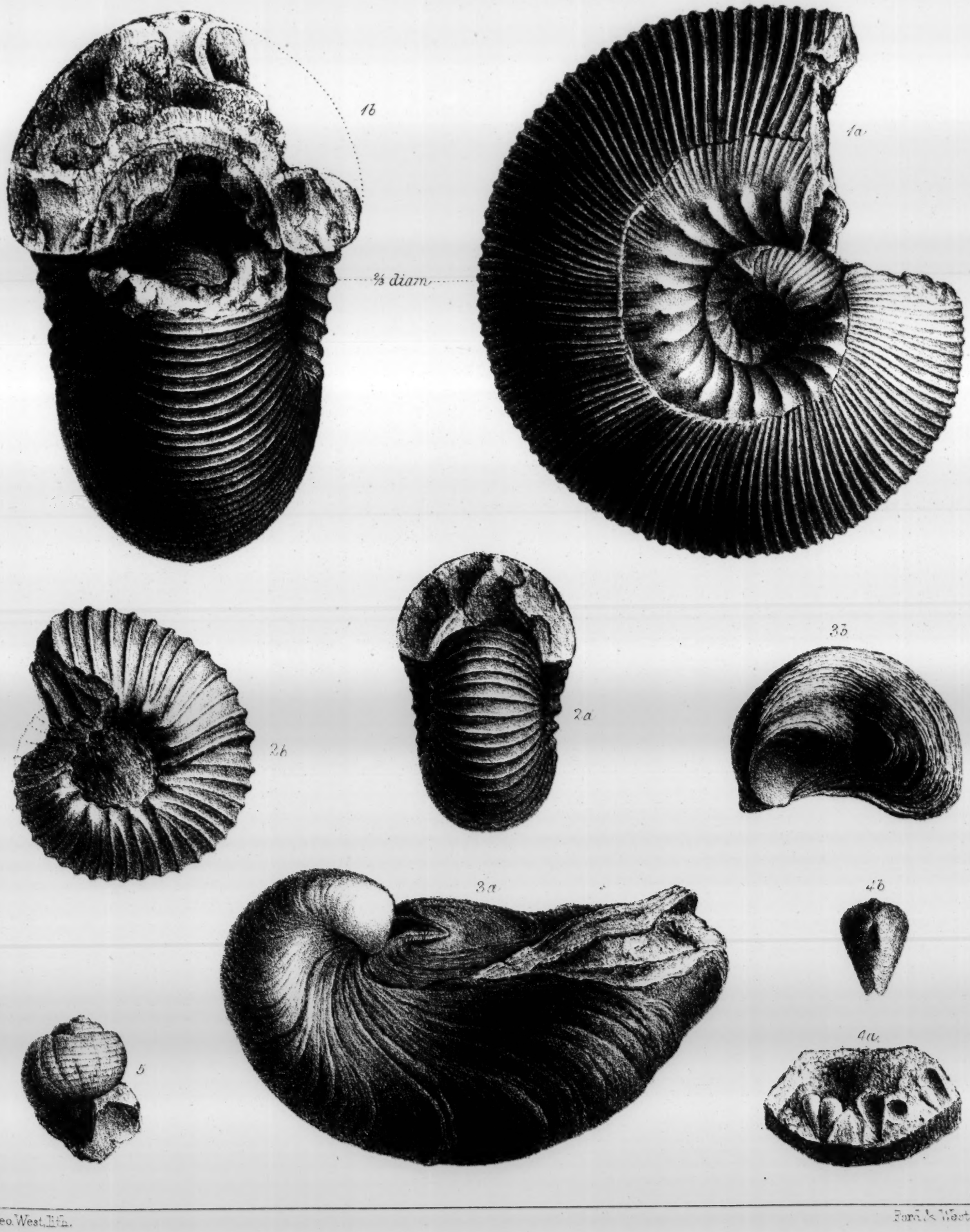
Geo. West. lith.

FOSSILS FROM SOUTH AFR



Ford & West. Imp

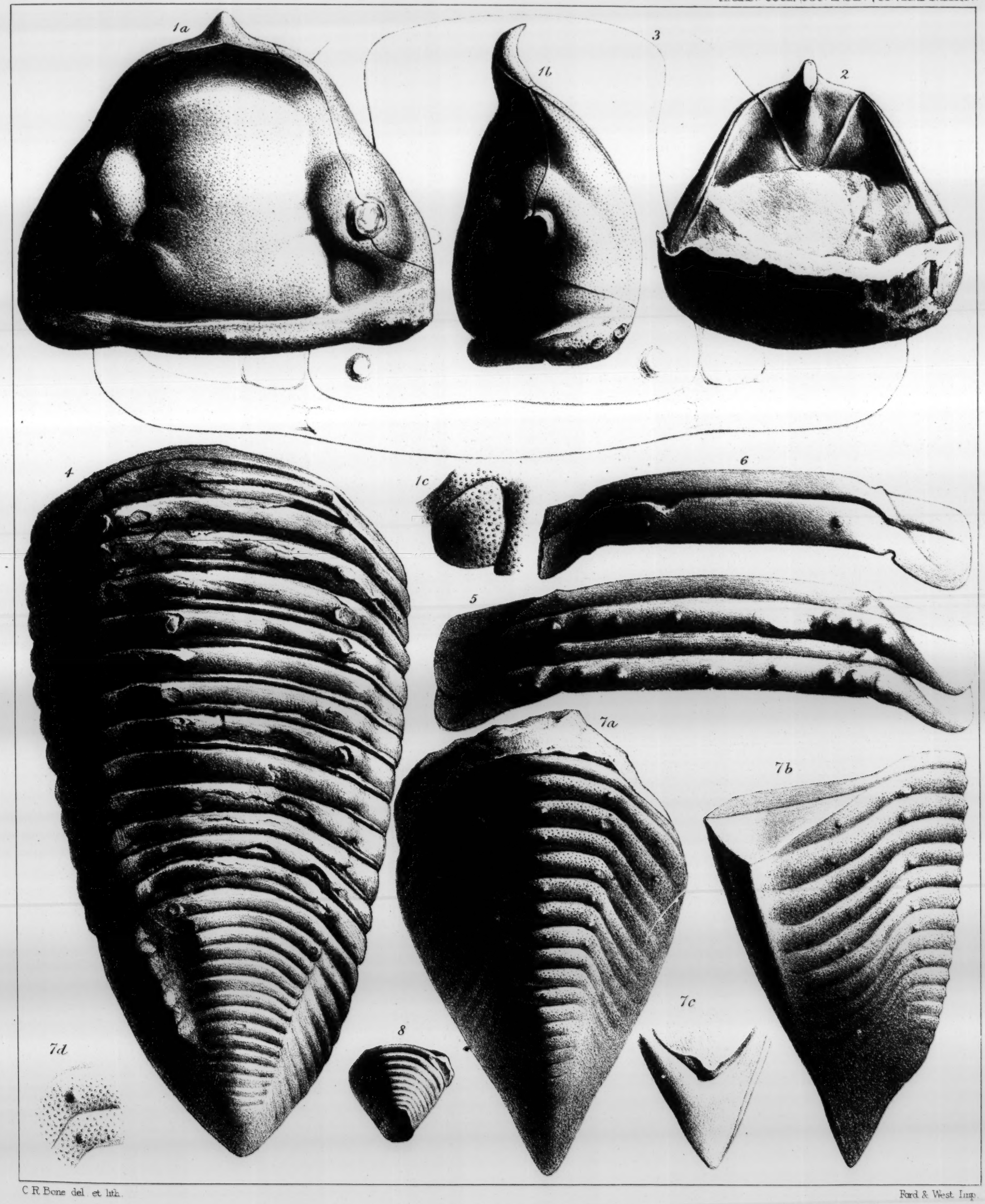
AFRICA *(Secondary)*



Geo. West, Bfn.

Ford & West, Imp.

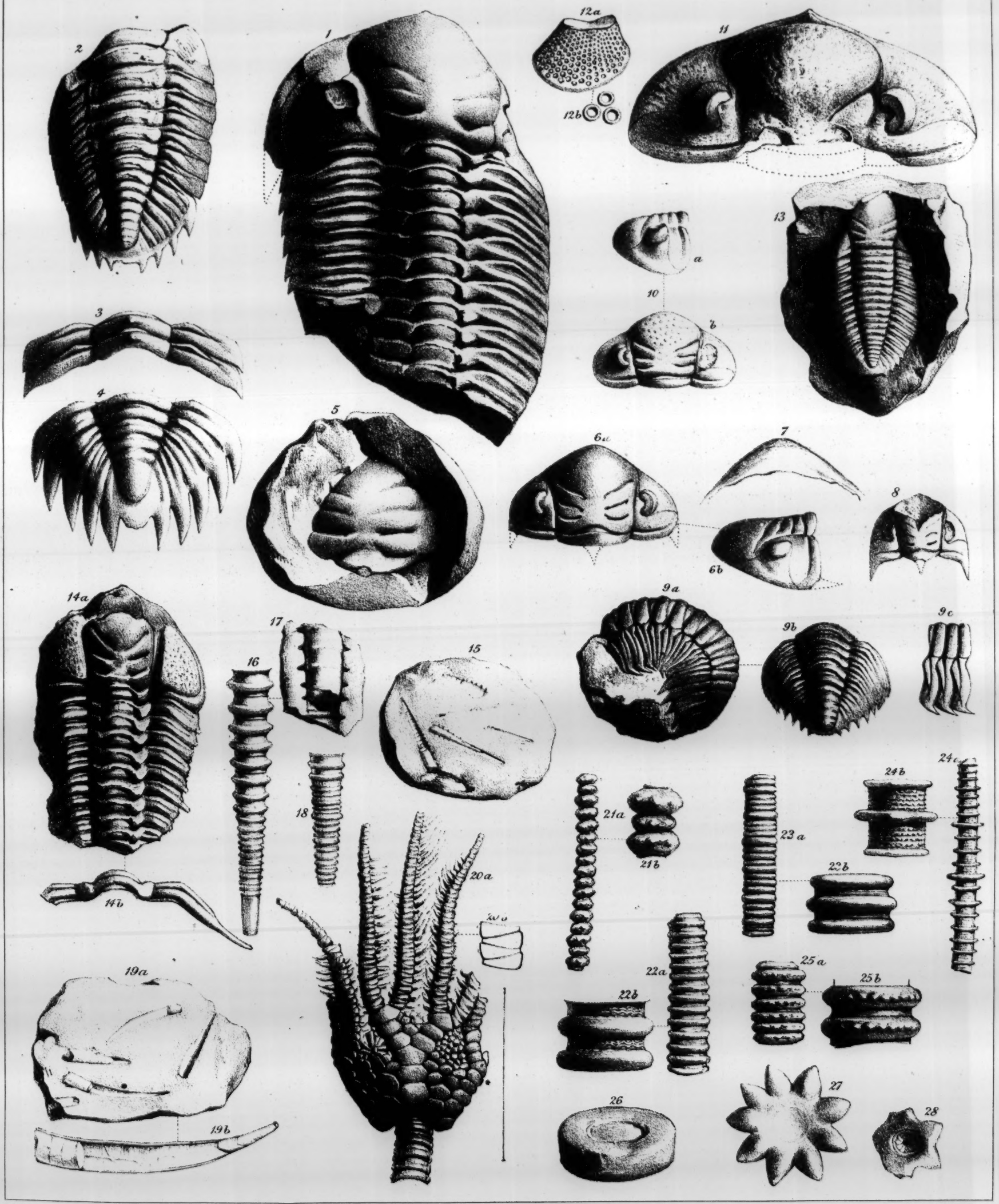
FOSSILS FROM SOUTH AFRICA. *(Secondary.)*



C R Bone del et lith.

Ford & West Imp.

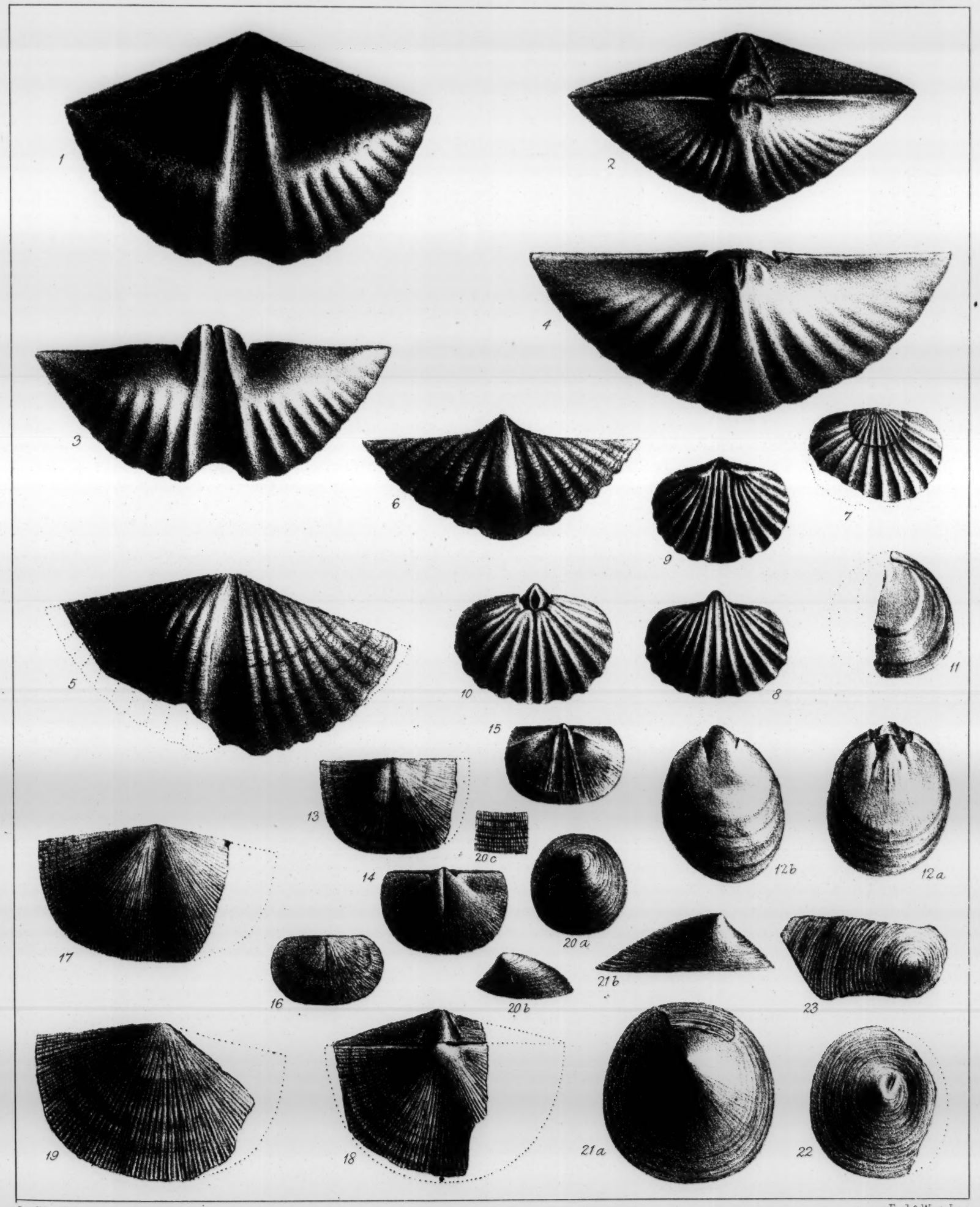
FOSSILS FROM SOUTH AFRICA (*Palæozoic.*)



C. R. Bone del. et lith.

Ford & West. Imp.

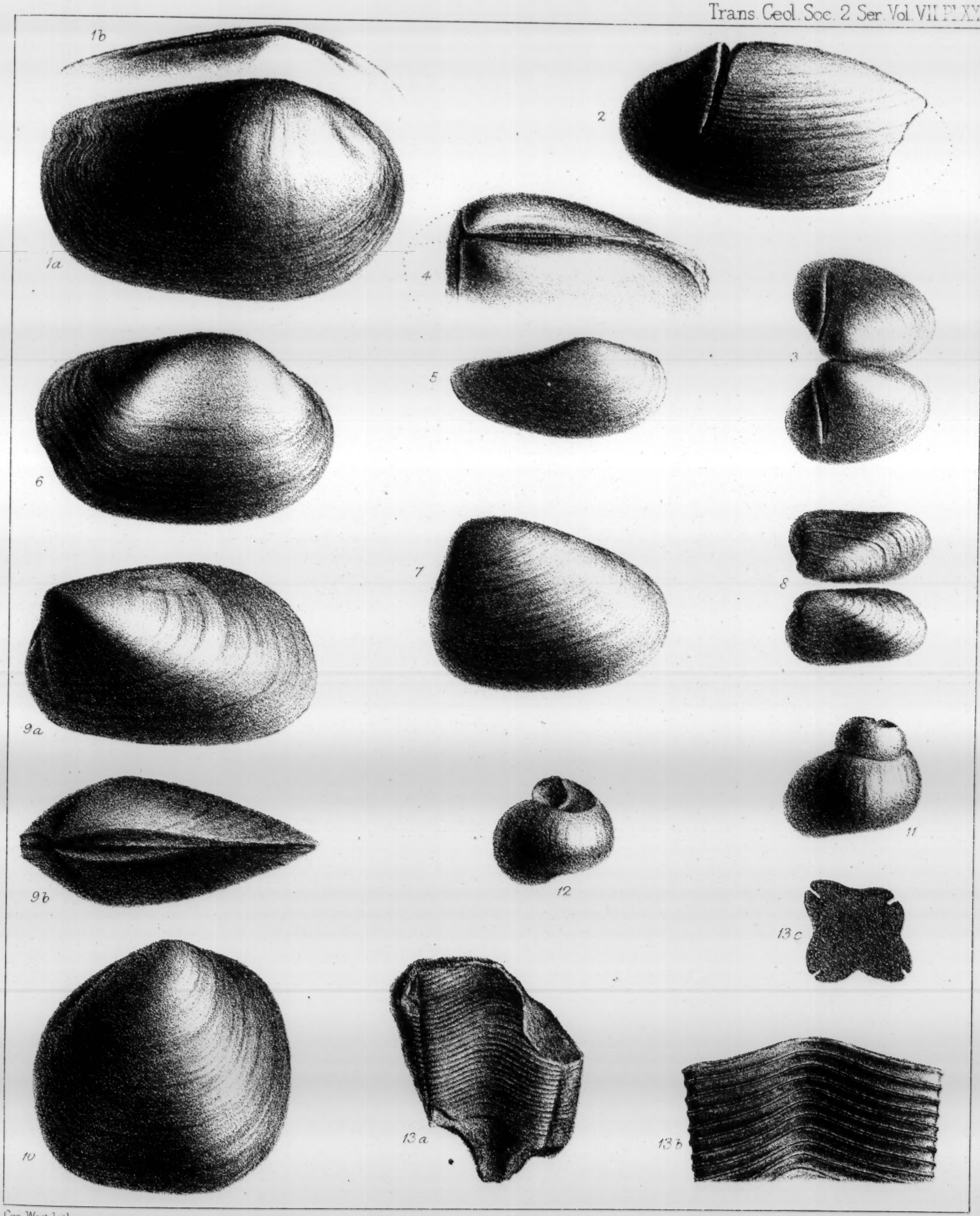
FOSSILS FROM SOUTH AFRICA. *(Palæozoic)*



Geo West Lith.

Ford & West Imp.

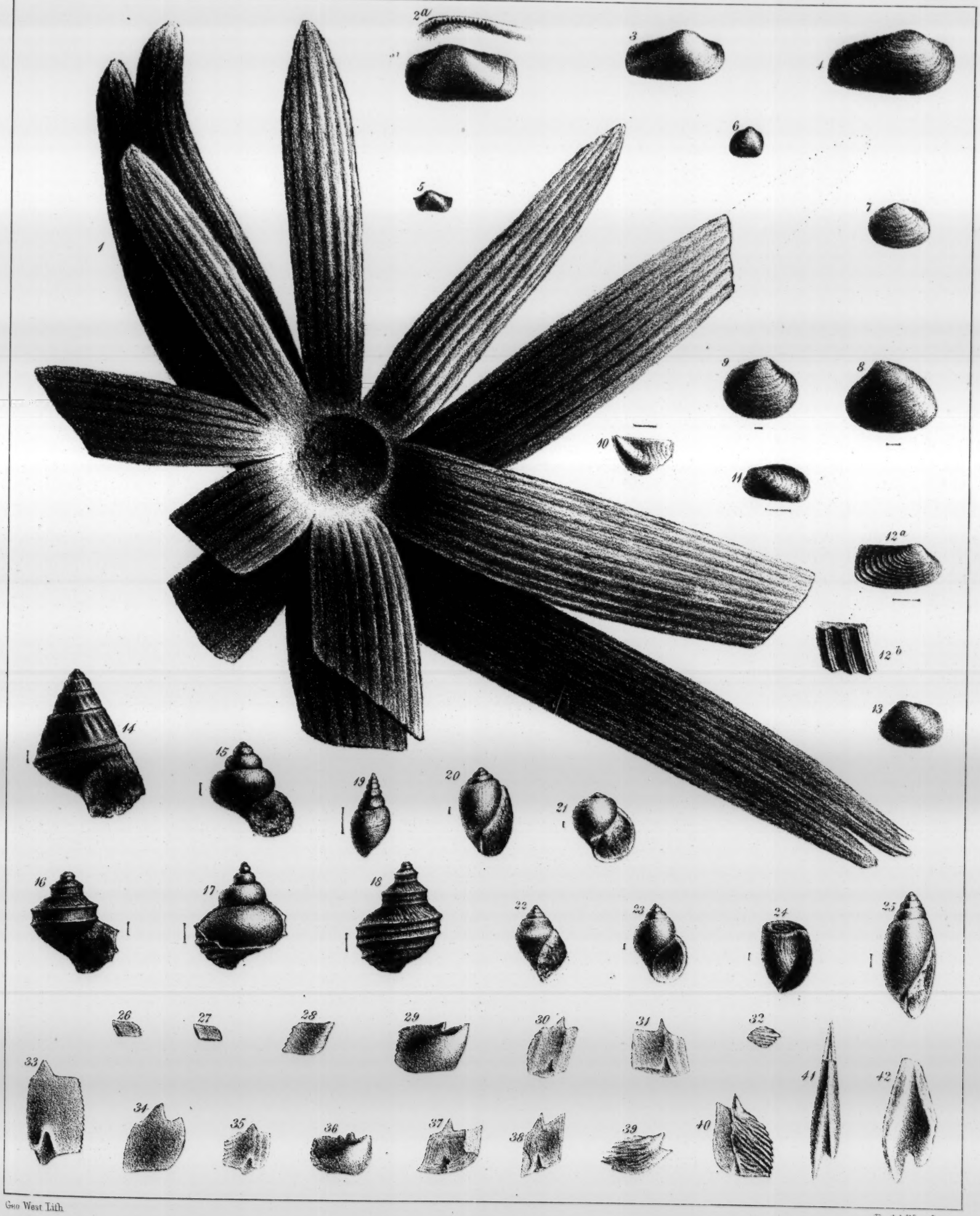
FOSSILS FROM SOUTH AFRICA *(Palæozoic.)*



Geo. West Lith.

Ford & West Imp.

FOSSILS FROM SOUTH AFRICA. *(Palæozoic)*



Geo West Lith

Ford & West Imp

FOSSILS FROM SOUTH AFRICA *(Secondary)*

Oblique View of Forehead .



Day & Son Lith.rs to the Queen

Oblique View of Forehead.



Jos. Dinkel. del. et lith.

Day & Son, Lith.rs to The Queen.

Dicynodon tigriceps. (Owen.)

Dicynodon tigriceps.

Dicynodon tigriceps.



½

Jos. Dinkel, Lith.

Ford & West, Imp.

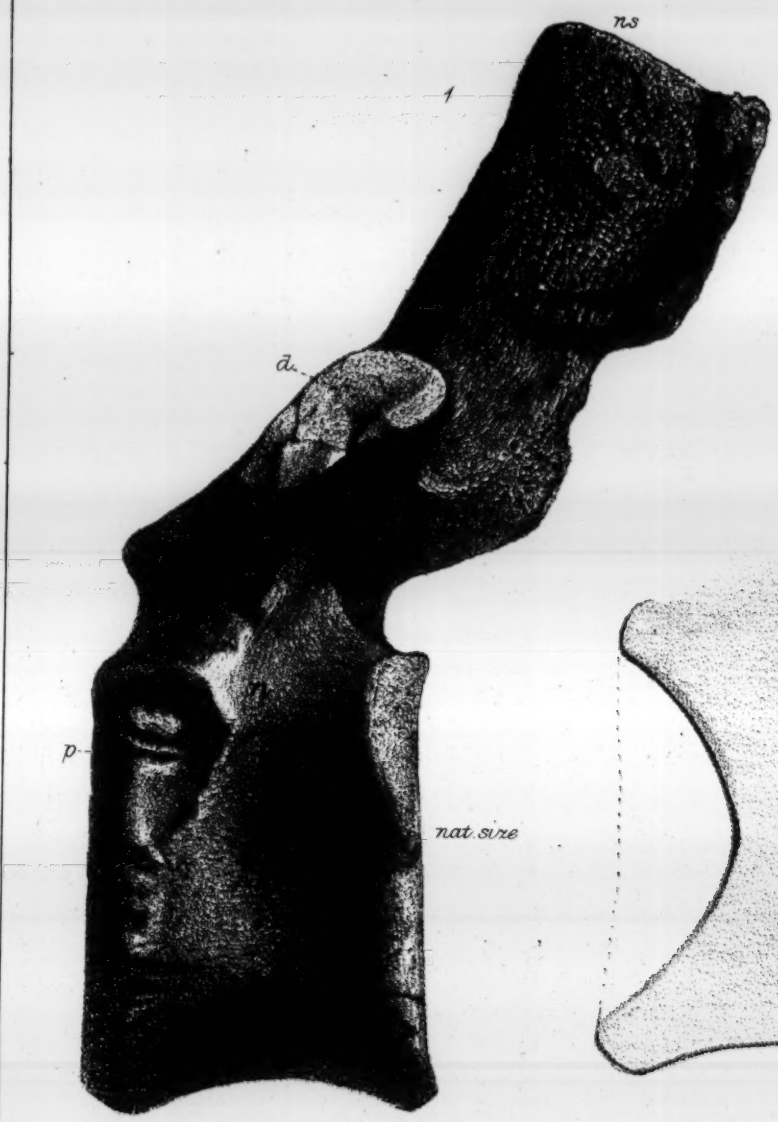
Dicynodon tigriceps.

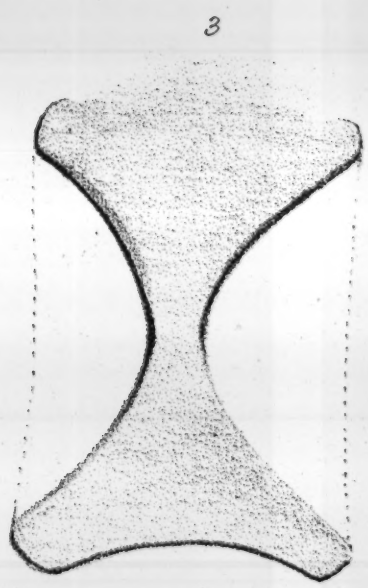


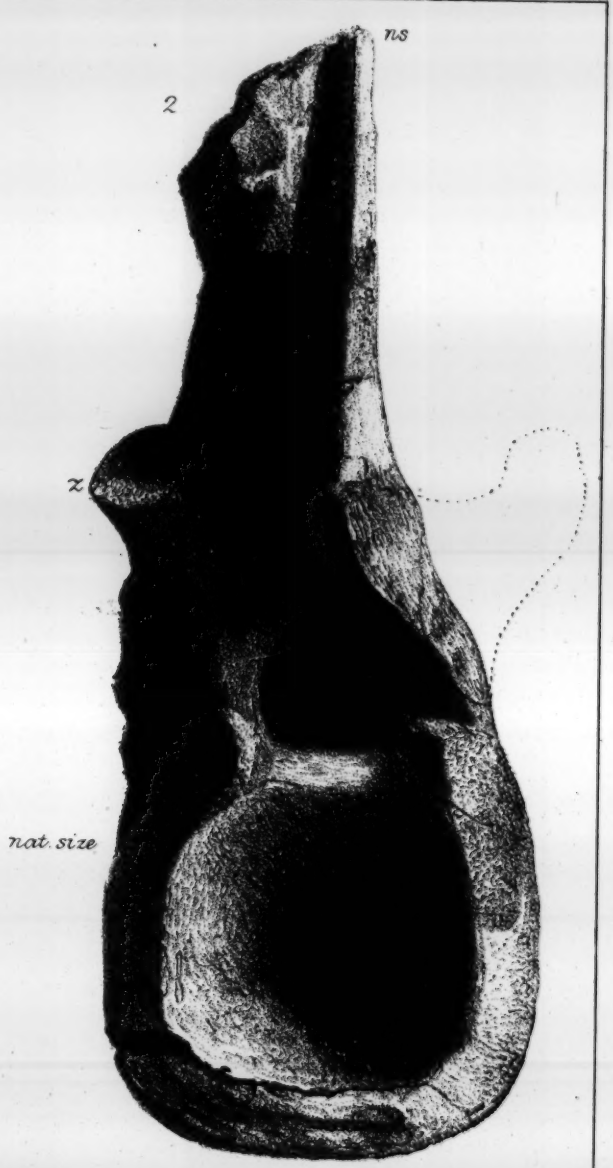
Dickel, Lith.

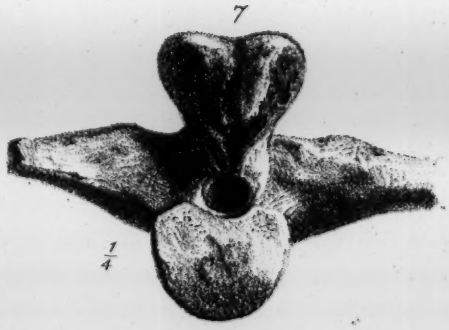
Ford & West, Imp.

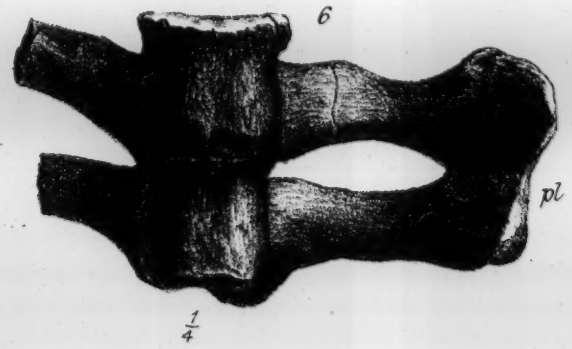
Dicynodon tigriceps.



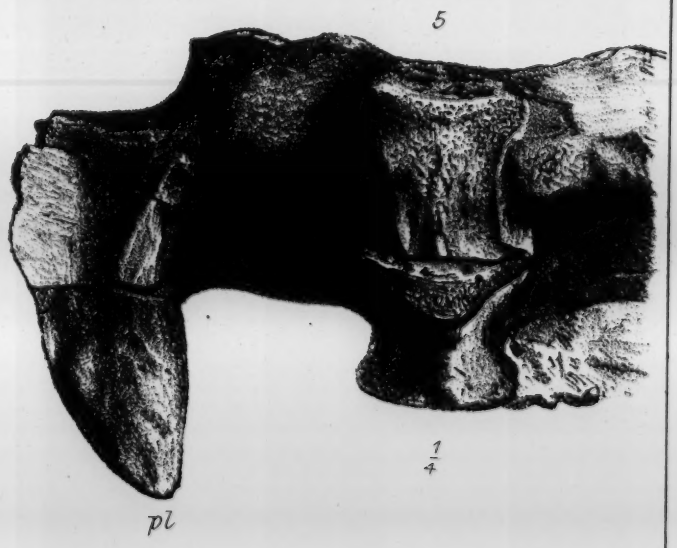








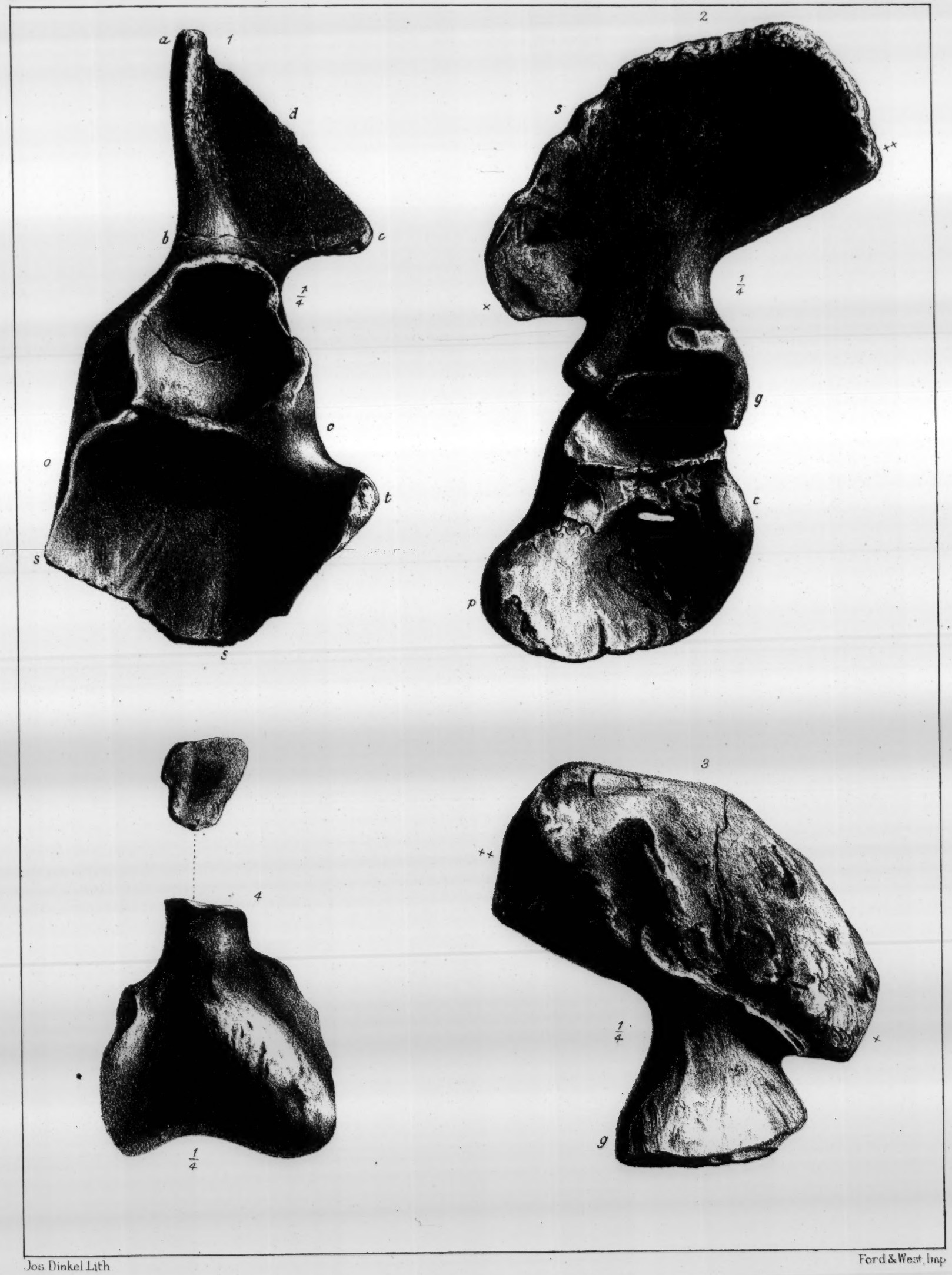




Jos. Dinkel. Lith

Ford & West, Imp

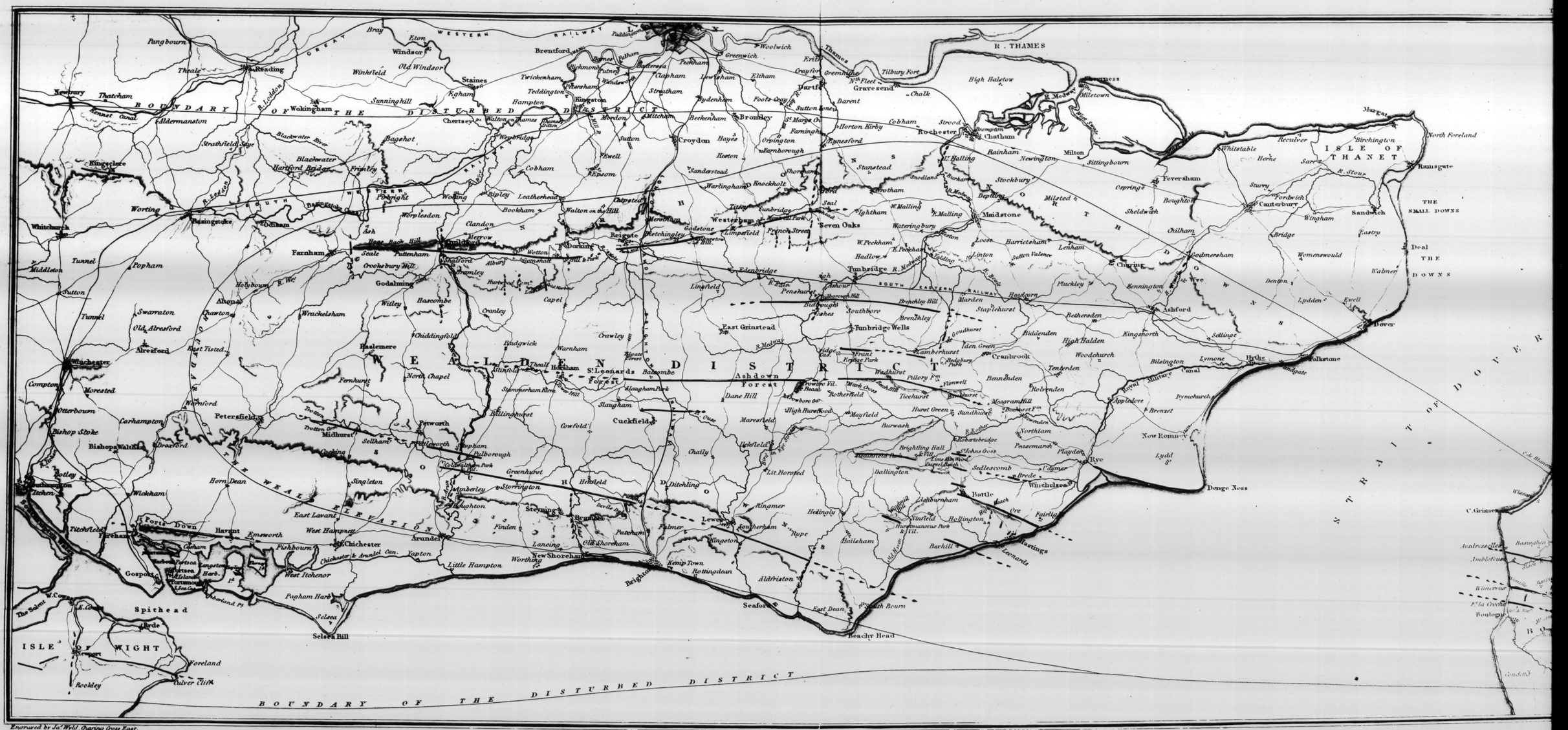
REMAINS OF DICYNODON. SOUTH AFRICA.

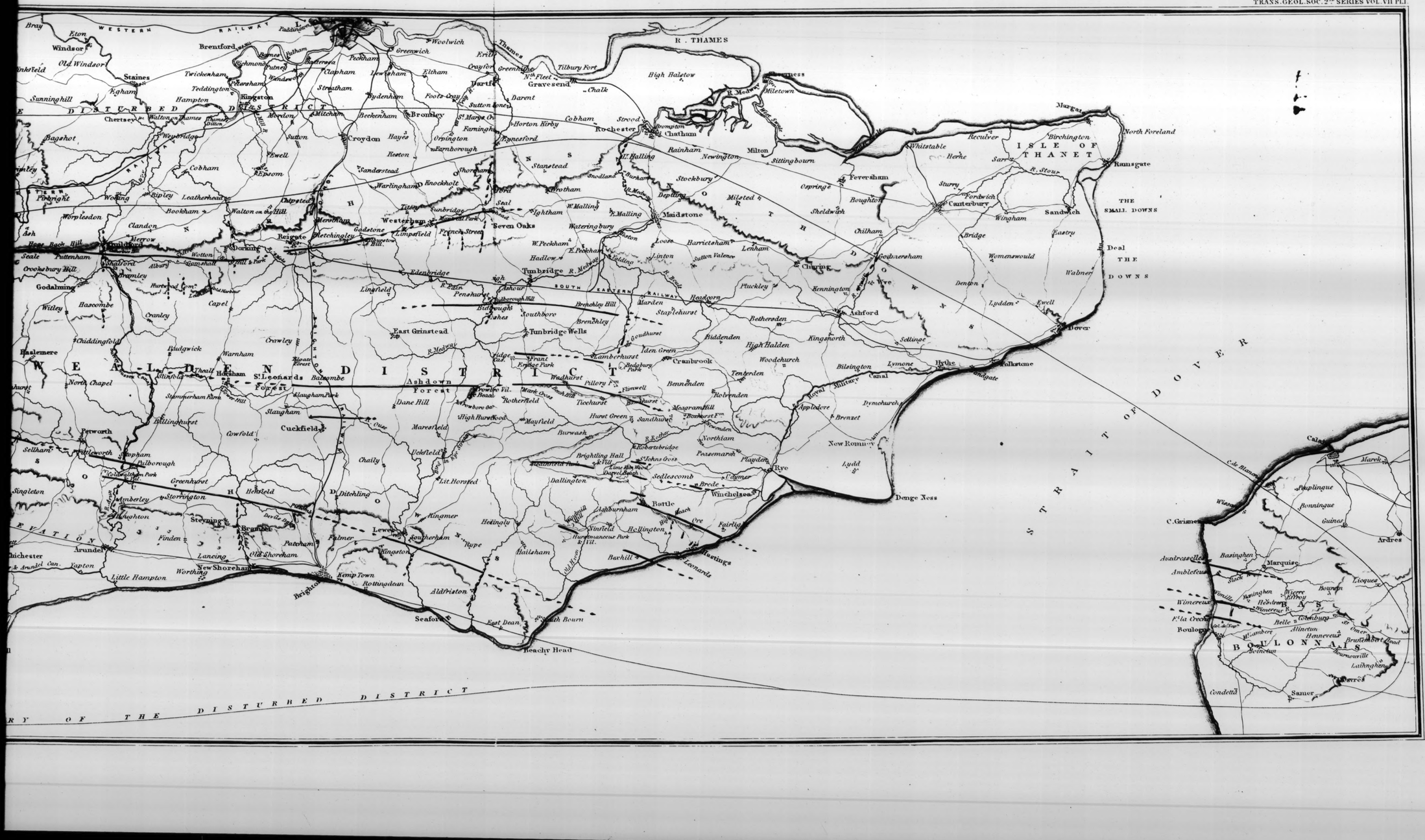


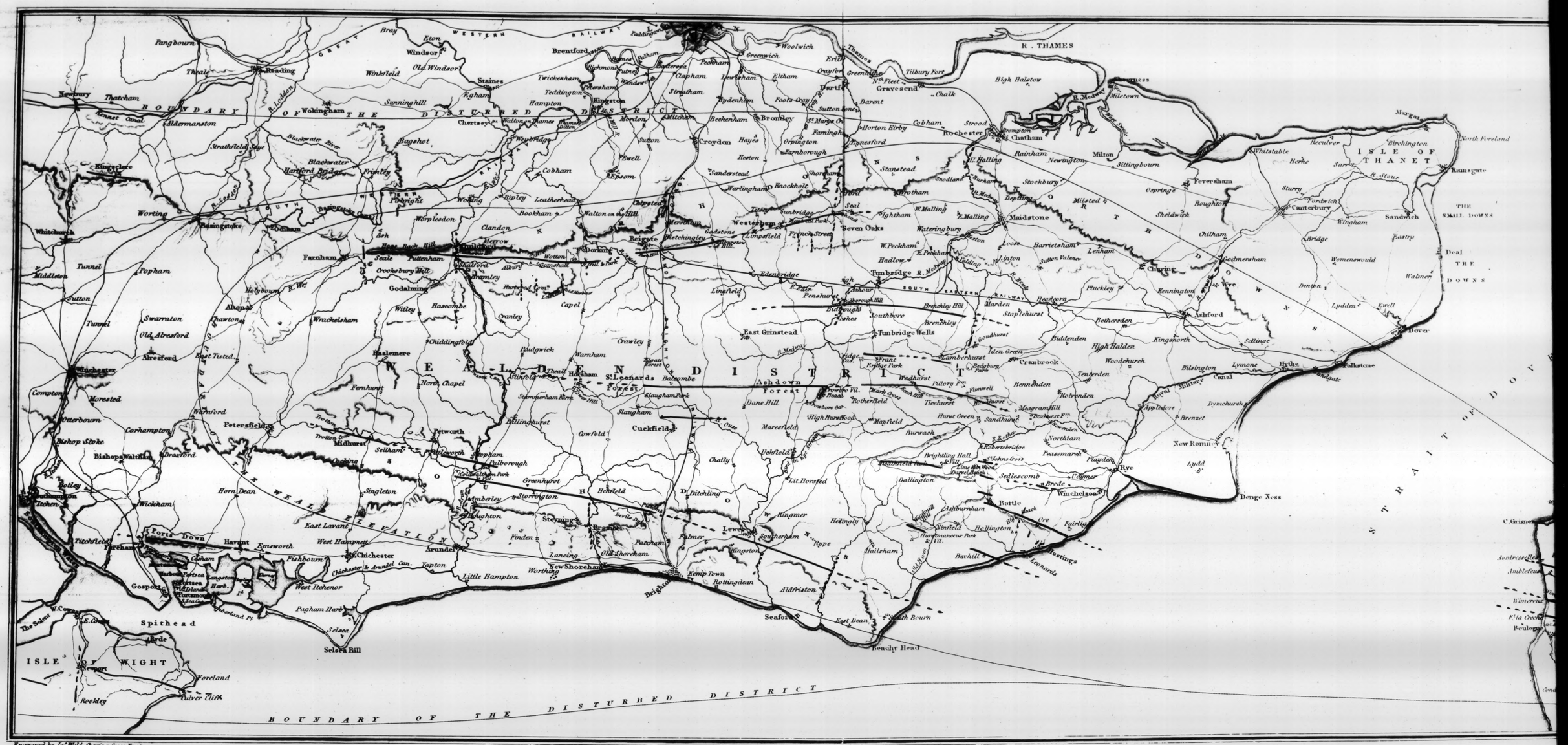
Jos Dinkel Lith

Ford & West, Imp

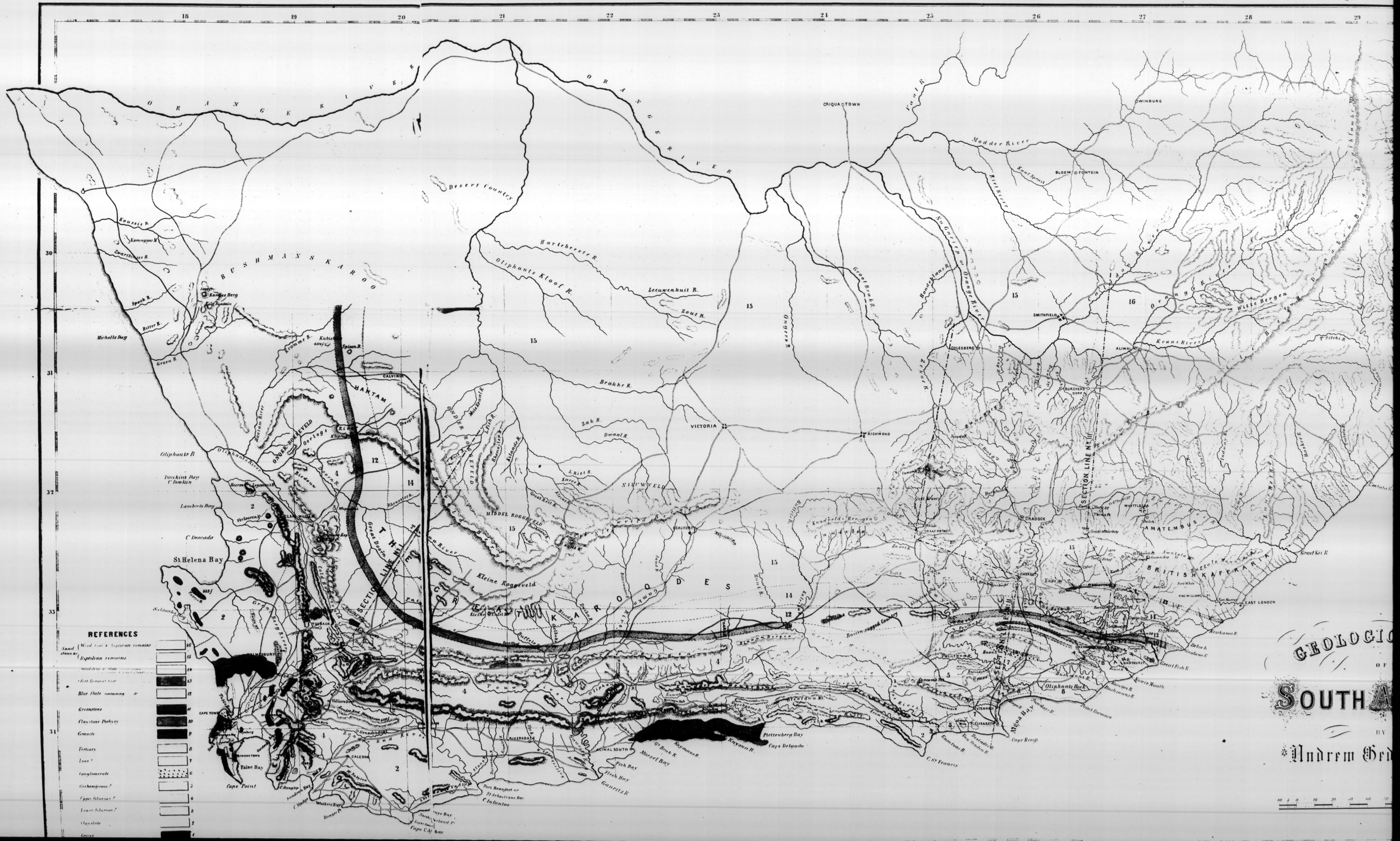
REMAINS OF DICYNODON. SOUTH AFRICA.

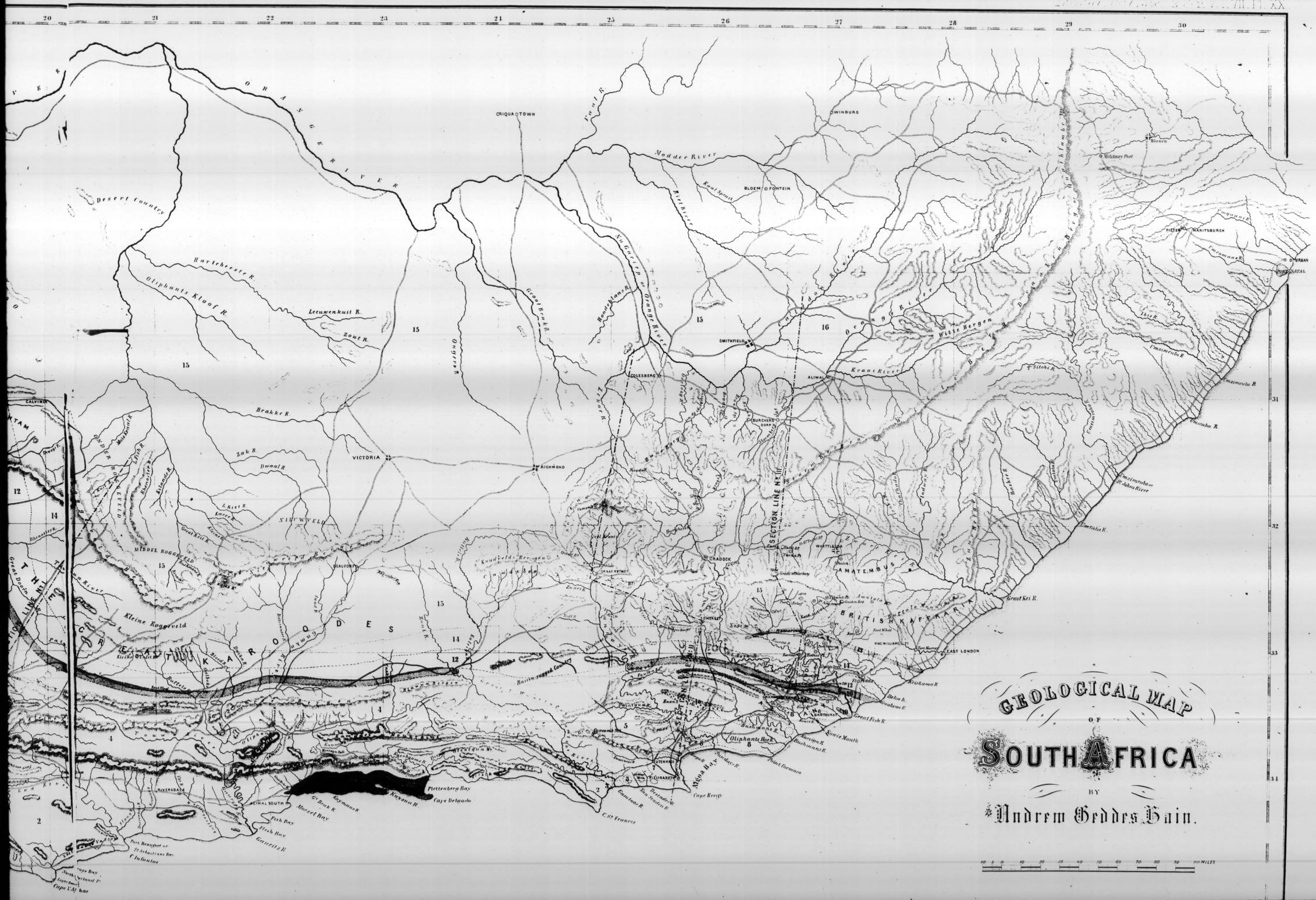

BOUNDARY OF THE DISTURBED DISTRICT
GREAT WESTERN RAILWAY
SOUTH EASTERN RAILWAY
R. THAMES
NORTH DOWNS
THE SMALL DOWNS
THE DOWNS
ISLE OF THANET
ISLE OF WIGHT
NEATH DENDIP DISTRICT
WEALD ELEVATION
STRAIT OF DOVER
Reading
Windsor
Staines
Chertsey
Kingston
Croydon
Bromley
Dartford
Gravesend
Rochester
Chatham
Maidstone
Canterbury
Margate
Ramsgate
Sandwich
Deal
Dover
Folkestone
Ashford
Hythe
Romney
Rye
Winchelsea
Hastings
Battle
Lewes
Brighton
Worthing
Arundel
Chichester
Portsmouth
Gosport
Southampton
Winchester
Farnham
Guildford
Godalming
Dorking
Reigate
Epsom
Kingston
Richmond
Tunbridge Wells
East Grinstead
Cranbrook
Tenterden
Hythe
Seaford
Beachy Head
Denge Ness
Selsea Bill
Spithead
Engraved by Ja.s Wyld. Charing Cross East.


R. THAMES
Thames
Windsor
Old Windsor
Staines
Brentford
Richmond
Kingston
Hampton
Chertsey
Walton on Thames
Weybridge
Bagshot
Cobham
Epsom
Ewell
Sutton
Croydon
Bromley
Hayes
Orpington
Farnborough
Keston
Sanderstead
Warlingham
Knockholt
Titsey
Westerham
Seven Oaks
Sevenoaks
Godstone
Limpsfield
French Street
Reigate
Merstham
Redhill
Chipstead
Woking
Ripley
Leatherhead
Bookham
Walton on the Hill
Worplesdon
Clandon
Merrow
Guildford
Godalming
Witley
Hascombe
Cranley
Chiddingfold
Haslemere
Ludgwick
Warnham
Capel
Dorking
Wotton
Albury
Shalford
Bramley
Crocksbury Hill
Scale
Puttenham
Hurtwood Comm.
Crawley
Ifield
Edenbridge
Lingfield
Penshurst
Ashour
Tunbridge
Tunbridge Wells
East Grinstead
Groombridge
Speldhurst
Bidborough
Southboro'
Brenchley Hill
Brenchley
Marden
Staplehurst
Headcorn
Pluckley
Kennington
Ashford
Biddenden
High Halden
Kingsnorth
Sellinge
Hythe
Folkestone
Dover
Denton
Lydden
Ewell
Margate
North Foreland
Birchington
Reculver
Whitstable
Herne
Sarre
Ramsgate
R. Stour
Sturry
Fordwich
Canterbury
Sandwich
Wingham
Eastry
Bridge
Deal
Walmer
Womenswould
Goodnersham
Chilham
Boughton
Sheldwich
Faversham
Stockbury
Newington
Sittingbourn
Milton
Rainham
Ct Halling
Snodland
Burham
Stanstead
Otford
Shoreham
Eynsford
Farningham
Horton Kirby
Cobham
Strood
Rochester
Chatham
Brompton
Gravesend
Tilbury Fort
Greenwich
Woolwich
Deptford
Peckham
Camberwell
Clapham
Battersea
Putney
Fulham
Hammersmith
Twickenham
Teddington
Sunninghill
Egham
Streatham
Tooting
Wandsworth
Mitcham
Morden
Beckenham
Dulwich
Norwood
Sydenham
Foots Cray
Sutton Lane
Darent
Dartford
Crayford
Erith
Thames
Tilbury Fort
Gravesend
Chalk
High Halstow
R. Medway
Milton
Milletown
Queenborough
Sheppey
Isle of Sheppey
Whitstable
Reculver
Herne
Sarre
Birchington
North Foreland
Margate
Ramsgate


BOUNDARY OF THE DISTURBED DISTRICT
WEALDEN DISTRICT
Ashdown Forest
St Leonards Forest
Bagshot Heath
Hindhead
Blackdown
Leith Hill
Pitch Hill
Hog's Back
Box Hill
Reigate Hill
Banstead Downs
Epsom Downs
Walton Heath
Farthing Down
Coulsdon Common
Riddlesdown
Titsey Hill
Keston Common
Hayes Common
Addington Hills
Shirley Common
Croydon Common
Norwood
Dulwich
Peckham Rye
Blackheath
Shooters Hill
Eltham Common
Plumstead Common
Woolwich Common
Erith Marshes
Crayford Marshes
Dartford Heath
Swanscombe Marshes
Northfleet
Gravesend
Chalk
Higham
Cobham Park
Shorne
Ashenden
Hartlip
Bredgar
Bapchild
Tonge
Milton
Sittingbourne
Murston
Key Street
Eastchurch
Leysdown
Warden Point
Minster
Sheerness
Queenborough
Isle of Sheppey
Harty Ferry
Elmley
Conyer
Faversham
Ospringe
Boughton
Sheldwich
Chilham
Challock
Godmersham
Womenswould
Wingham
Sandwich
Deal
Walmer
Ringwould
Kingsdown
Dover
Folkestone
Sandgate
Hythe
Lympne
Bilsington
Aldington
Ruckinge
Appledore
Brenzett
Romney Marsh
New Romney
Lydd
Dungeness
Rye
Rye Harbour
Winchelsea
Pevensey
Pevensey Bay
Eastbourne
Beachy Head
Seaford
Newhaven
Brighton
Kemp Town
Rottingdean
Worthing
New Shoreham
Old Shoreham
Lancing
Little Hampton
Bognor
Selsea Bill
Pagham Harb.
Chichester
Arundel
Petworth
Midhurst
Haslemere
Godalming
Guildford
Farnham
Aldershot
Bagshot
Windsor
Eton
Slough
Reading
Wokingham
Basingstoke
Newbury
Thatcham
Kingsclere
Whitchurch
Andover
Stockbridge
Romsey
Southampton
Netley
Hythe
Calshot Castle
Cowes
East Cowes
Newport
Yarmouth
Freshwater
Needles
Totland Bay
Alum Bay
Sandown
Shanklin
Ventnor
St Catherine's Point
Blackgang Chine
Brook
Rookley
Culver Cliff
Foreland
Bembridge
Spithead
Isle of Wight
The Solent
Portsmouth
Gosport
Fareham
Titchfield
Emsworth
Havant
Horndean
Petersfield
Liphook
Hindhead
Guildford
Dorking
Leatherhead
Epsom
Kingston
Richmond
Brentford
Hounslow
Staines
Chertsey
Weybridge
Walton on Thames
Esher
Hampton
Twickenham
Putney
Battersea
Clapham
Peckham
Deptford
Greenwich
Woolwich
Thames
R. THAMES
Tilbury Fort
High Halstow
R. Medway
Rochester
Chatham
Strood
Cobham
Gravesend
Northfleet
Dartford
Crayford
Erith
Bexley
Sidcup
Eltham
Lewisham
Dulwich
Norwood
Croydon
Beckenham
Bromley
Sydenham
Forest Hill
Penge
Streatham
Tooting
Wandsworth
Battersea
Chelsea
Kensington
Hammersmith
Fulham
Putney
Richmond
Kingston
Teddington
Twickenham
Hampton
Sunbury
Shepperton
Chertsey
Walton on Thames
Weybridge
Woking
Ripley
Send
Guildford
Godalming
Haslemere
Petersfield
Liphook
Hindhead
Farnham
Aldershot
Basingstoke
Bagshot
Windsor
Eton
Slough
Reading
Wokingham

R. THAMES
ISLE OF THANET
THE SWALE
THE DOWNS
THE DOWNS
THE DOWNS


ORANGE RIVER
ORANGE RIVER
BUSHMANS KARROO
Desert country
Hartbreste R.
Olifhants Kloof R.
Leeuwenkuit R.
Zout R.
Brakke R.
Zak R.
Dwaal R.
VICTORIA
RICHMOND
CRIQUA TOWN
Fraai R.
Modder River
Kaal Spruit
Riet River
BLOEM O FONTEIN
OWINBURG
Caledon River
Orange River
Witte Bergen
Kraai River
SMITHFIELD
COLLESBERG
ALIWAL N.
Zuurberg
Zeekoe R.
Groot Kraai R.
Bonte Blaauw R.
Aas Gorlen or Orange River
Onder Riet R.
Kleine Roggeveld
Great Roggeveld
MIDDEL ROGGEVELD
NIEUWEVELD
Great Karroo
Great Fish R.
Kei R.
Bashee R.
Umtata R.
Umzimvubu R.
Umtamvuna R.
Umzimkulu R.
Tugela R.
Buffalo R.
Keiskama R.
Great Kei R.
Sitchi R.
Kraai R.
Orange R.
Vaal R.
Zeekoe R.
Groen R.
Ratel R.
Kouga R.
Kromme R.
Spioen B.
Kabiesberg
Michelle Bag
Bitter R.
Spruit R.
Zwartlintjes R.
Kamaggas M.
Koussie R.
Olifhants R.
Doorn R.
Berg R.
Verlooren R.
Lambert Bay
C Deseada
St Helena Bay
Saldanha Bay
Great Berg River
Jonkers
Kaapse Berg
Table Mountain
Table Bay
Robben I.
CAPE TOWN
Wynberg
SIMONSTOWN
False Bay
Cape Point
C Hangklip
Hottentots Holland Mountains
Hottentots Holland Kloof
Zonder End River
Zwarte Berg
Olifhants River
Olifhants Bay
Jordan River
Doorn R.
Buffeljags R.
Duyvenhoks R.
Breede River
Riet R.
Kuils R.
Kuils Gat
Kuils Kloof
Kuils Poort
Kuils Rivier
Tulbagh
Piquetberg
Piquetberg Mountains
Piquetberg Kloof
Piquetberg Road
Great Drift
Great Doorn R.
Rhenosters
Rhenosters R.
Verlooren R.
Olifhants R.
Olifhants River
Olifhants Bay
Dassen I.
Dassen Bay
Saldanha Bay
Langebaan Lagoon
Langebaan Road
Hottentots Holland
Hottentots Holland Kloof
Zonder End River
Zwarte


GEOLOGICAL MAP
OF
SOUTH AFRICA
BY
Andrew Geddes Bain.
ORANGE RIVER
Desert Country
Hartebeester R.
Olifants Kloof R.
Leeuwenkuil R.
Zout R.
Brakke R.
Zak R.
Dwaal R.
VICTORIA
RICHMOND
CRADOCK
BEAUFORT
MIDDEL ROGGEVELD
Kleine Roggeveld
GREAT KAROO DES
CRIQUA TOWN
Nodder River
Roode Sprut
BLOEM FONTEIN
Zeekoe River
Great Brak R.
Bonte Plaat R.
Orange River
SMITHFIELD
COLESBERG
ALIWAL N.
BURGHERS DORP
Kraai River
Witte Bergen
DWINBURG
Wesleyan
Military Post
PIETERMARITZBURG
DURBAN
NATAL
Umzimcula R.
Umzimvubu R.
St Johns River
Umtata R.
Great Kei R.
AMATEMBUS
BRITISH KAFFRARIA
EAST LONDON
Buffalo R.
Keiskama R.
Great Fish R.
Kowie R.
Bushmans R.
Sunday R.
Algoa Bay
Cape Recife
Plettenberg Bay
Cape Delgado
Keyman R.
Gt Brak R.
Mossel Bay
Fish Bay
Hlesk Bay
Gourits R.
Port Beaufort or St Sebastians Bay
C. Infanton
C. St Francis
Point Formosa
SECTION LINE N.S III
SECTION LINE N.S II
10 5 0 10 20 30 40 50 60 70 80 90 100 MILES

GEOLO

SOUTH

*Andrew

ORANGE RIVER

ORANGE RIVER

BUSHMANS KAROO

Desert Country

Hartbeester R.

Oliphants Kloof R.

Leeuwenkuit R.

Zout R.

Brakke R.

Zak R.

Dwaal R.

Onder Roggeveld

Middel Roggeveld

Kleine Roggeveld

Great Karoo

Great Roggeveld Mountains

Great Escarpment or Orange River

Nieuwveld Mountains

Nieuwveld

Sneeuwberg

Cold Sneeuwberg

Roode Berg

Witte Bergen

Kraai River

Modder River

Riet River

Caledon River

Orange River

Vaal R.

Great Fish R.

Great Kei R.

Kabousie R.

Komnaggas M.

Zwartbooisies R.

Spoek R.

Bitter R.

Groen R.

Michelle Bay

Oliphants R.

Oliphants River

Lamberts Bay

C Deseada

St Helena Bay

Saldanha Bay

Table Mountain

Table Bay

Robben Island

CAPE TOWN

Cape Point

False Bay

Hottentots Holland

Simons Town

Stellenbosch

Paarl

Tulbagh

Worcester

Williamsdorp

Riversdale

Caledon

Swellendam

Zwellendam

Mossel Bay

Plettenberg Bay

Cape Delgado

Knysna R.

Keurboom R.

Port Beaufort or St Sebastians Bay

C Infantas

Cape L'Agulhas

Walkers Bay

Danger Pt

Hermanus

Caledon Bay

Standen Bay

Table Bay

Saldanha Bay

Lambert Bay

Verlooren R.

Olifants River

Berg River

Breede River

Gouritz R.

Gamtoos R.

Zwartkops R.

Sundays R.

Great Brak R.

Little Brak R.

Kleinemonds R.

Duiwenhoks R.

Kouga R.

Kromme R.

Spioen R.

Kabiesmans R.

Montagu River

Onder Roggeveld

Oorlogs Kloof

Rietfontein

Rhenoster R.

Great Doorn R.

Little Doorn R.

Buffels R.

Kuils R.

Karee R.

Kleinemonds R.

Kleine Doorn R.

Kleine Buffels R.

Kleine Karee R.

Great Karee R.

Kleine Karee R.

Kleine Zwart R.

Groot Brak R.

Onrust

Zwart Kops R.

Bonte Bergen

Bonte Bergen R.

Zwart Berg

Zwart Berg R.

Kraai River

Modder River

Riet River

Caledon River

Orange River

Vaal R.

Great Fish R.

Great Kei R.

Kabousie R.

Komnaggas M.

Zwartbooisies R.

Spoek R.

Bitter R.

Groen R.

Michelle Bay

Oliphants R.

Oliphants River

Lamberts Bay

C Deseada

St Helena Bay

Saldanha Bay

Table Mountain

Table Bay

Robben Island

CAPE TOWN

Cape Point

False Bay

Hottentots Holland

Simons Town

Stellenbosch

Paarl

Tulbagh

Worcester

Williamsdorp

Riversdale

Caledon

Swellendam

Zwellendam

Mossel Bay

Plettenberg Bay

Cape Delgado

Knysna R.

Keurboom R.

Port Beaufort or St Sebastians Bay

C Infantas

Cape L'Agulhas

Walkers Bay

Danger Pt

Hermanus

Caledon Bay

Standen Bay

Table Bay

Saldanha Bay

Lambert Bay

Verlooren R.

Olifants River

Berg River

Breede River

Gouritz R.

Gamtoos R.

Zwartkops R.

Sundays R.

Great Brak R.

Little Brak R.

Kleinemonds R.

Duiwenhoks R.

Kouga R.

Kromme R.

Spioen R.

Kabiesmans R.

Montagu River

Onder Roggeveld

Oorlogs Kloof

Rietfontein

Rhenoster R.

Great Doorn R.

Little Doorn R.

Buffels R.

Kuils R.

Karee R.

Kleinemonds R.

Kleine Doorn R.

Kleine Buffels R.

Great Karee R.

Kleine Karee R.

Kleine Zwart R.

Groot Brak R.

Onrust

Zwart Kops R.

Bonte Bergen

Bonte Bergen R.

Zwart Berg

Zwart Berg R.

CRIQUATOWN

SWINBURG

BLOEMFONTEIN

SMITHFIELD

COLESBERG

ALIWAL

BURGHERS CORP

VICTORIA

RICHMOND

BEAUFORT

CRADOCK

GRAAF REINET

MIDDELBURG

SOMERSET

GRAHAMSTOWN

BATHURST

WHITTLESEA

KING WILLIAMS

EAST LONDON

FORT BEAUFORT

FORT HARE

FORT WILLIAMS

FORT MURRAY

FORT WHITE

FORT BROWN

FORT CUNYNGHAME

FORT ELIZABETH

Algoa Bay

Cape Recife

Mgwa Bay

Bushmans R.

Kowie R.

Blaauw Kranz R.

Sundays R.

Great Fish R.

Great Kei R.

Keiskamma R.

Buffalo R.

Kabousie R.

Komnaggas M.

Zwartbooisies R.

Spoek R.

Bitter R.

Groen R.

Michelle Bay

Oliphants R.

Oliphants River

Lamberts Bay

C Deseada

St Helena Bay

Saldanha Bay

Table Mountain

Table Bay

Robben Island

CAPE TOWN

Cape Point

False Bay

Hottentots Holland

Simons Town

Stellenbosch

Paarl

Tulbagh

Worcester

Williamsdorp

Riversdale

Caledon

Swellendam

Zwellendam

Mossel Bay

Plettenberg Bay

Cape Delgado

Knysna R.

Keurboom R.

Port Beaufort or St Sebastians Bay

C Infantas

Cape L'Agulhas

Walkers Bay

Danger Pt

Hermanus

Caledon Bay

Standen Bay

Table Bay

Saldanha Bay

Lambert Bay

Verlooren R.

Olifants River

Berg River

Breede River

Gouritz R.

Gamtoos R.

Zwartkops R.

Sundays R.

Great Brak R.

Little Brak R.

Kleinemonds R.

Duiwenhoks R.

Kouga R.

Kromme R.

Spioen R.

Kabiesmans R.

Montagu River

Onder Roggeveld

Oorlogs Kloof

Rietfontein

Rhenoster R.

Great Doorn R.

Little Doorn R.

Buffels R.

Kuils R.

Karee R.

Kleinemonds R.

Kleine Doorn R.

Kleine Buffels R.

Great Karee R.

Kleine Karee R.

Kleine Zwart R.

Groot Brak R.

Onrust

Zwart Kops R.

Bonte Bergen

Bonte Bergen R.

Zwart Berg

Zwart Berg R.

CRIQUATOWN

SWINBURG

BLOEMFONTEIN

SMITHFIELD

COLESBERG

ALIWAL

BURGHERS CORP

VICTORIA

RICHMOND

BEAUFORT

CRADOCK

GRAAF REINET

MIDDELBURG

SOMERSET

GRAHAMSTOWN

BATHURST

WHITTLESEA

KING WILLIAMS

EAST LONDON

FORT BEAUFORT

FORT HARE

FORT WILLIAMS

FORT MURRAY

FORT WHITE

FORT BROWN

FORT CUNYNGHAME

FORT ELIZABETH

Algoa Bay

Cape Recife

Mgwa Bay

Bushmans R.

Kowie R.

Blaauw Kranz R.

Sundays R.

Great Fish R.

Great Kei R.

Keiskamma R.

Buffalo R.

SECTION LINE N° III

SECTION LINE N° II

THIRD SECTION LINE

CAPE MOUNTAINS

KAMMANASSIE MOUNTAINS

KAMMANASSIE

KAMMANASSIE BERG

KAMMANASSIE KLOOF

KAMMANASSIE R.

KAMMANASSIE BERG

KAMMANASSIE KLOOF

KAMMANASSIE R.

BRITISH KAFFRARIA

AMATEMBUS

TOWN

TOWN

TOWN

GEOLOGICAL MAP
OF
SOUTH AFRICA
BY
Andrew Geddes Bain.

10 5 0 10 20 30 40 50 60 70 80 90 100 MILES

ORIQUA TOWN
SWINBURG
Modder River
BLOEMFONTEIN
Kaal Spruit
Riet River
Orange River
Caledon River
Desert Country
Hartebeests R.
Olifants Kloof R.
Leeuwenkuil R.
Zout R.
Brakke R.
Zak R.
Dmaal R.
Groote R.
Great Brak R.
Roode Klaas R.
Zak River
SMITHFIELD
COLESBERG
ALIWAL
BURGHERSDORP
VICTORIA
RICHMOND
Kraai River
Wilge Bergen
Drakensberg
Caledon R.
Orange River
Great Kei R.
Amatembus
BRITISH KAFFRARIA
KING WILLIAMS TT
EAST LONDON
Buffalo R.
Keiskamma R.
Great Fish R.
Kowie R.
Bushmans R.
Sunday R.
Zwartkops R.
Gamtoos R.
Kromme R.
Baviaans R.
Olifants Hoek
Mossel Bay
Cape Recife
Plettenberg Bay
Cape Delgado
Keyzers R.
Gt Brak R.
Mossel Bay
Fish Bay
Gourits R.
C. St Francis
Algoa Bay
Port Elizabeth
Uitenhage
Zwartkops R.
Sundays R.
Gamtoos R.
Baviaans R.
Kromme R.
Port Beaufort or St Sebastians Bay
C. Infanta
RIVERSDALE
CALEDON
Cape Town
Table Bay
Simons Bay
Cape L'Agulhas
Great Winterberg
Great Whitebeck
Zuurberg
Kouteveld Bergen
Witteberg
Roggeveld
Kleine Roggeveld
Nieuwveld
Middel Roggeveld
Great Karroo
Little Karroo
Section Line No. III
Section Line No. II
Section Line No. I
Natal
Durban
Umzimkulu R.
Umtamvuna R.
Umtata R.
Umtentu R.
Umzimvubu or St Johns River
Pondoland
Natalia
Military Post
Pietermaritzburg
Umgeni R.
Umlazi R.
Tugela R.
Buffalo R.
Klipplaat R.
Kaaimans R.
Kouga R.
Kabousie R.
Kromme R.
Zwartkops R.
Sundays R.
Gamtoos R.
Baviaans R.
Olifants Hoek
Mossel Bay
Cape Recife
Plettenberg Bay
Cape Delgado
Keyzers R.
Gt Brak R.
Fish Bay
Gourits R.
C. St Francis
Algoa Bay
Port Elizabeth
Uitenhage
Zwartkops R.
Sundays R.
Gamtoos R.
Baviaans R.
Kromme R.
Port Beaufort or St Sebastians Bay
C. Infanta
RIVERSDALE
CALEDON
Cape Town
Table Bay
Simons Bay
Cape L'Agulhas

GEOLOGICAL SECTIONS OFSOUTH AFRICA.

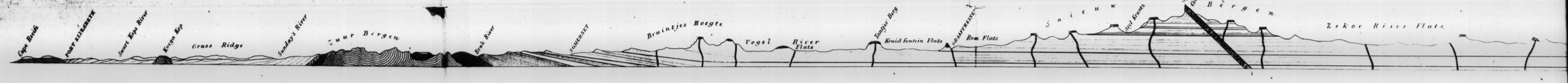
BY ANDREW GEDDES AIN.

Nº I.



Section from Table Mountain to Middel Roggeveld

Nº II.



Section from Cape Recife to Lower Zekoe River near nge River

Nº III.



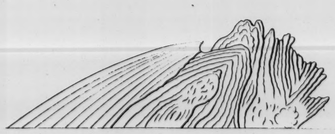
Section from Kowie mouth to Caledon R.

Nº V.



Contorted upper Silurian Sand-stone, Karoo Poort.

Nº VI.



Contorted Carboniferous Sandstone, Burnt Kraal *near* Grahams Town.

Nº IV.



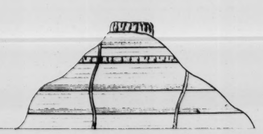
Sections of Lion's Hill.

Nº VII



Fault in the Lacustrine Strata, Buffels River Great Karoo.

Nº VIII.



Mountain in the Amatemba *Country, shewing 2 beds of Greenstone & 2 dikes of different ages.*

REFERENCES.

- *Tertiary*
- *Lias?*
- *Conglomerate*
- *Carboniferous?*
- *Upper Silurian?*
- *Lower Silurian?*
- *Clay slate*
- *Gneiss*

Scale for Vertical extents.

Scale for Horizontal extents.

0 3 6 12 18 24 36 Miles

NOTE.

Sandstone &c.

Fort Beaufort Grit

Sandstone &c. Plain

Greenstone

Clay stone Porphyry

Granite

GEOLOGICAL SECTIONS OFSOUTH AFRICA.

BY ANDREW GEDDES AIN.

Nº I.



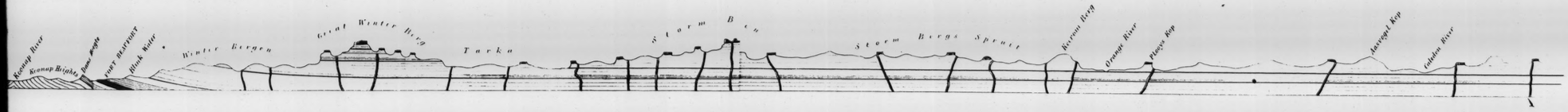
Section from Table Mountain to Middel Roggeld

Nº II.



Section from Cape Recife to Lower Zekoe River near nge River

Nº III.

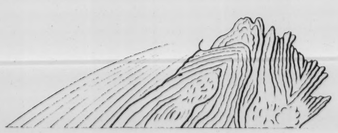


Section from Kowie mouth to Caledon R

Nº VI.



-stone,



Centerial Carboniferous Sandstone, Burnt Kraal near Grahams Town.

Nº IV.



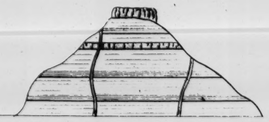
Sections of Lion's Hill.

Nº VII



Fault in the Lacustrine Strata, Buffels River Great Karoo.

Nº VIII.



Mountain in the Amatembu *Country, shewing 2 beds of Greenstone & 2 dikes of different ages.*

Scale for Vertical extents.

Scale for Horizontal extents.

0 1 2 3 4 5 10 15 20 25 30 Miles

NOTE.

REFERENCES.

- Sandstone Cr — Wood Coal & Reptilian remains
- Sandstone Cr — Reptilian remains
- Feet Banded Grit
- Sandstone Cr — Plant remains
- Greenstone
- Claystone Porphyry
- Granite

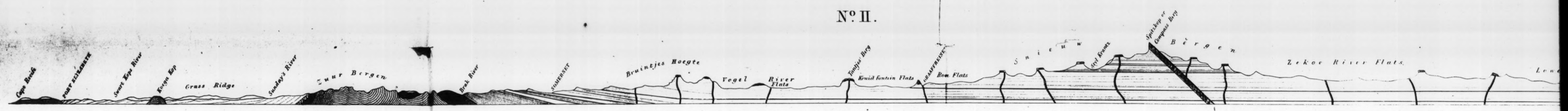
BY ANDREW GEDDES AIN.

Nº I.



Section from Table Mountain to Middel Reg'ld

Nº II.



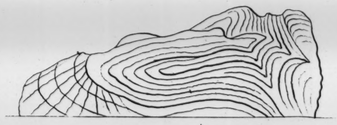
Section from Cape Receife to Lower Zekoe River near nge River

Nº III.



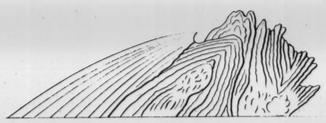
Section from Kowie mouth to Caledon R.

Nº V.



Contorted upper Silurian Sand-stone,
Karoo Poort.

Nº VI.



Contorted Carboniferous Sandstone, Burnt Kraal
near Grahams Town.

Nº IV.



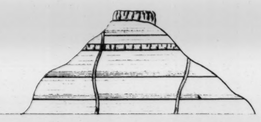
Sections of Lion's Hill.

Nº VII



Fault in the Lacustrine Strata,
Buffels River Great Karoo.

Nº VIII.



Mountain in the Amatembu *Country,*
shewing ? beds of Greenstone & ? dikes of different ages.

REFERENCES.

- *Tertiary*
- *Lias?*
- *Conglomerate*
- *Carboniferous?*
- *Upper Silurian?*
- *Lower Silurian?*
- *Clayslate*
- *Gneiss*

Scale for Vertical extents.

Scale for Horizontal extents.

0 3 6 12 18 24 36 Miles

NOTE.

REFERENCES

- *Sandstone Gr* { *Weed Coal & Reptilian*; *Reptilian remains*
- *Fort Beaufort Grit*
- *Sandstone Gr Plant remains*
- *Greenstone*
- *Claystone Porphyry*
- *Granite*

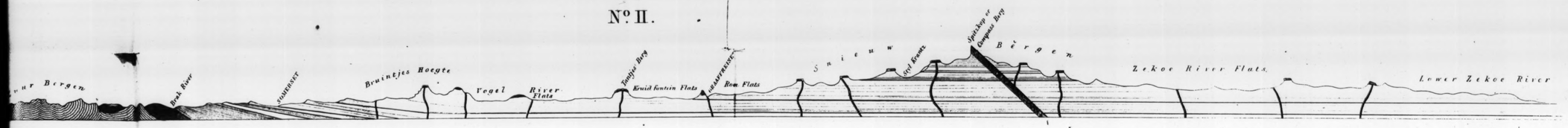
BY ANDREW GEDDES AIN.

Nº I.



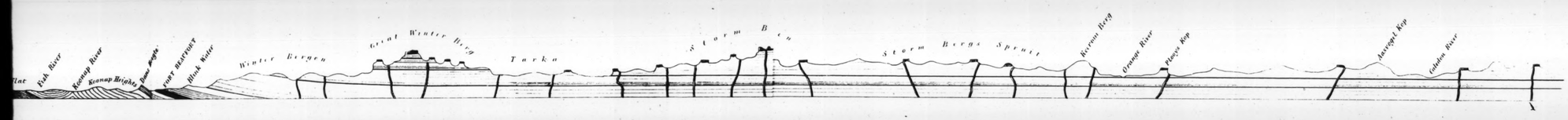
Section from Table Mountain to Middel Roggeld

Nº II.



Section from Cape Recife to Lower Zekoe River near nge River

Nº III.



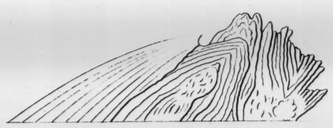
Section from Kowie mouth to Caledon R

Nº V.



rian Sand-stone,
Poort.

Nº VI.



Contorted Carboniferous Sandstone, Burnt Kraal
near Grahams Town.

Nº IV.



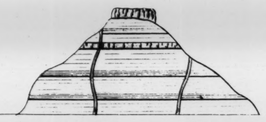
Sections of Lion's Hill.

Nº VII



Fault in the Lacustrine Strata,
Buffels River Great Karoo.

Nº VIII.



Mountain in the Amatemba *Country,*
shewing ? beds of Greenstone & ? dikes of different ages.

Scale for Vertical extents.

Scale for Horizontal extents.

30 Miles

NOTE.

REFERENCES.

Sandstone Cc { Wood Coal & Reptilian remains / Reptilian remains
Fort Beaufort Grit
Sandstone Cc Plant remains

Greenstone
Claystone Porphyry
Granite